EAST AFRICA HIGH COMMISSION

EAST AFRICAN AGRICULTURE
AND
FORESTRY RESEARCH ORGANISATION

ANNUAL REPORT
1955

RECORD OF RESEARCH

For the Period 1st January 1954 to 30th June 1955

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SIR BERNARD KEEN, D.Sc., F.Inst.P., F.R.S.,
Director of the East African Agriculture and
Forestry Research Organisation,
1947 to 1954.
From an original painting in oils
by Mary A. E. Vardy

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THE STAFF OF THE EAST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANISATION AT THE 30th JUNE 1955

DIRECTORATE

Sir Bernard A. Keen, D.Sc., F.Inst.P., F.R.S. (On leave pending retirement, from November 1954) .... *Director*

H. H. Storey, C.M.G., M.A., Ph.D., F.R.S. (On leave pending retirement) .... *Deputy Director, Acting Director (from November 1954)*

H. C. Pereira, B.Sc., Ph.D. .... *Deputy Director (from June 1955)*

M. H. French, O.B.E., M.A., Ph.D., Dip. Agric. .... *Head of Joint Animal Industry Division*

RESEARCH DIVISIONS

SOIL PHYSICS

(H. C. Pereira, B.Sc., Ph.D.) .... *Physicist-in-Charge*
P. H. Hosegood .... *Scientific Assistant*
Ezekiel Kasavuli .... *Laboratory Assistant*

SOIL CHEMISTRY

H. F. Birch, B.Sc., Ph.D. .... *Chemist-in-Charge*
P. R. Hesse, B.Sc., Ph.D., A.R.I.C. .... *Soil Chemist*
Leonard Nganga .... *Laboratory Assistant*

GENERAL CHEMICAL ANALYSIS

M. T. Friend, M.Sc., A.R.I.C. .... *Analyst*

SPECTROCHEMISTRY

G. T. Chamberlain .... *Spectrochemist*
A. J. Searle .... *Scientific Assistant*

SOIL SURVEY

G. H. Gethin Jones, M.Sc. .... *Soil Surveyor-in-Charge*
R M. Scott, B.Sc. .... *Soil Surveyor*

MICROBIOLOGY

J. W. Millbank, B.Sc., Ph.D.	*Microbiologist (Seconded to Rothamsted Experimental Station, England)*

PLANT PHYSIOLOGY

J. Glover, M.Sc.	*Plant Physiologist*

PLANT BREEDING AND GENETICS

L. R. Doughty, B.Sc., N.D.A.	*Geneticist-in-Charge*
D. L. Jennings, B.Sc.	*Geneticist*
D. W. Gourlay, B.A.	*Field Experimentalist*
T. Graham	*Scientific Assistant*
George Williams	*Laboratory Assistant*
Barnabas Kifua	*Laboratory Assistant*

PLANT PATHOLOGY

(H. H. Storey, C.M.G., M.A., Ph.D., F.R.S.)	*Pathologist-in-Charge*
Miss F. M. L. Sheffield, D.Sc.	*Plant Pathologist*
Mrs. A. K. Ryland, B.Sc.	*Scientific Assistant*
Ferdinand Wamagata	*Laboratory Assistant*

FOREST ENTOMOLOGY

J. C. M. Gardner, C.I.E., A.R.C.S., D.I.C., F.R.E.S., Dip. For.	*Entomologist-in-Charge*
Mrs. E. J. Brown, M.A.	*Scientific Assistant*
Michael Kangeri	*Laboratory Assistant*

INSECTICIDE RESEARCH

K. S. McKinlay, B.Sc.	*Entomologist-in-Charge of C.A.I.R.U., Ilonga, Tanganyika*

SYSTEMATIC BOTANY

P. J. Greenway, O.B.E., D.Sc., F.L.S.	*Botanist-in-Charge of the E.A. Herbarium*
B. Verdcourt, B.Sc., Ph.D.	*Botanist*

FORESTRY

A. L. Griffith, O.B.E., M.A., D.Sc.	*Silviculturist-in-Charge*
B. E. St. L. Stuart, B.A.	*Silviculturist*

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D. W. Duthie, M.A., Ph.D., F.R.I.C.	*Biochemist*
J. Quarterman, Ph.D., A.R.I.C.	*Biochemist*
G. H. Lampkin, B.Sc., N.D.A.	*Geneticist*
(A. Rogerson, B.Sc., Ph.D.)	*Nutrition Chemist (E.A.V.R.O.)*
(Mrs. M. D. King)	*Personal Secretary (E.A.V.R.O.)*
H. P. Ledger, N.D.D.	*Farm Manager*
A. F. Dent, Dip. Agric., Dip. Dairying	*Assistant Farm Manager*
Mayda Kapitapa	*Farm Overseer*
(Musa Kinyanjui)	*Laboratory Assistant (E.A.V.R.O.)*

AGRICULTURAL STATISTICS

P. Robinson, B.A., Dip. Stat.	*Statistician*
Edward Stephen Waweru	*Laboratory Assistant*
Henry Thuku Rimi	*Laboratory Assistant*

HORTICULTURE

W. B. May, F.R.H.S.	*Horticulturist*

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Mrs. S. Evans	*Acting Librarian*
Joseph Okakah	*Bookbinder*

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(D. W. Duthie, M.A., Ph.D., F.R.I.C.)	*Editor*
Mrs. M. Y. Robinson	*Assistant Editor*
Mrs. P. D. Hosegood	*Assistant Editor (from May 1955)*

PLANT QUARANTINE STATION

(Miss F.M.L. Sheffield, D.Sc.,	*Pathologist-in-Charge*
Mrs. G. A. Quinion	*Horticulturist*

ADMINISTRATION

ADMINISTRATION AND ACCOUNTS

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(B. Whitehead)	(*Accountant, posted from Accountant General's Department*)
Miss M. A. E. Vardy	*Personal Secretary to Director*
Mrs. M. May	*Personal Secretary*
Mrs. V. C. T. Knight	*Stenographer/Secretary*
Mrs. W. Griffith	*Clerical Assistant*
Miss J. J. Newill	*Clerical Assistant*
Mrs. R. B. Gibson	*Registry Clerk*
(B. B. Purohit)	(*Accounts Clerk, posted from Accountant General's Department*)
(S. I. Mascarhenas)	(*Accounts Clerk, posted from Accountant General's Department*)
(D. A. Patel)	(*Cashier, posted from Accountant General's Department*)
Matthew N. Waweru	*Administrative Clerk*

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L. R. F. D'Souza	*Storekeeper*
Sher Mohamed	*Artizan*
Vir Singh	*Artizan*
Dahyalal Sunderji	*Artizan*
Arthur Robert	*Artizan*
Jan Mohamed	*Overseer*
Geoffrey Mburu	*Stores Clerk*

ATTACHED COLONIAL DEVELOPMENT AND WELFARE SCHEMES

ECOLOGICAL TRAINING SCHEME

C. G. Trapnell, O.B.E., B.A.	*Ecologist-in-Charge*
D. I. Nicholson, B.Sc.	*Attached from Government of North Borneo*
J. G. Wilson, C.D.A.	*Attached from Department of Agriculture, Uganda*
W. D. Clayton, B.Sc., A.R.C.S.	*Colonial Research Student, Left October* 1954
C. F. Hemming, B.A.	*Attached from Desert Locust Survey until September* 1954

TERMITE RESEARCH SCHEME

W. A. Sands, B.Sc., A.R.C.S., D.I.C.	*Research Officer (Attached to British Museum)*
W. Wilkinson, B.Sc., M.I.Biol.	*Research Officer*
R. M. C. Williams, B.Sc., M.I.Biol.	*Research Officer*

COLONIAL RESEARCH FELLOWSHIP

V. F. Eastop, Ph.D.	*Entomologist for Aphid Research until March* 1954

INTRODUCTION

1. In November 1954, Sir Bernard Keen, F.R.S., left East Africa on leave pending retirement. With this report, therefore, the first phase of the Organisation's development covering the years 1948 to 1955 comes to an end. It has seen the conversion of a wattle forest into a developed Research station, with administrative, laboratory and library buildings, and a small residential township. It has seen the expansion of the small scientific staff that remained after the war in the East African Agricultural research Institute at Amani into the present Organisation of twenty-seven senior research officers in some fifteen scientific divisions, with a considerable record of research to their credit.

2. This first phase is indissolubly associated with the name of Sir Bernard Keen. Under his guidance the layout of the 1600 acres of land at Muguga presented by the Government of Kenya was planned ; and under his influence architects and engineers designed the buildings and the plant providing services to them. The research establishment and its programme of research were initiated by him. Throughout the Organisation's period of active research Sir Bernard Keen's leadership has been felt by all divisions. He steered the Organisation through many administrative and financial difficulties and carried a heavy burden of responsibility.

3. Sir Bernard Keen's departure deprives East Africa of a leader in agricultural research at a time when large developments are in progress.

4. Dr. E. W. Russell, M.A., Ph.D., F. Inst. P., has been appointed to succeed Sir Bernard Keen. He is expected to arrive in East Africa in November 1955. For the intervening twelve months Dr. H. H. Storey assumed charge of the Organisation. He had served as Deputy Director from 1948 and was himself on leave pending retirement early in 1956. In the post of Deputy Director, he was succeeded by Dr. H. C. Pereira in June 1955.

5. A number of other staff changes have occurred. Mr. P. Robinson has retired from his post as Statistician. Mr. K. S. McKinlay has transferred to the service of the Colonial Insecticides Committee, after serving for about a year in charge of the Committee's research unit at Ilonga, Tanganyika Territory. New appointments to the research staff are Dr. J. Quarterman as Biochemist to the Animal Industry Division, Dr. J. W. Millbank as Microbiologist (but in training at Rothamsted Experimental Station until 1956) and Mr. G. H. Lampkin, Geneticist to the Animal Industry Division (in transit from the United Kingdom at the end of the reporting period). Scientific Assistants appointed are Mr. A. J. Searle (Spectrochemistry) and Mrs. F. J. Brown (Forest Ento-

mology). Count Starzeński retired for reasons of health, after serving as Scientific Assistant in the E.A. Herbarium for seven years.

6. Doctorates in Philosophy have been awarded to Dr. B. Verdcourt and Dr. V. F. Eastop for work done during their service in the Organisation. The latter returned in 1955 to the United Kingdom on the expiry of his Colonial Fellowship.

7. Col. G. G. Robson was appointed Administrative Secretary in December 1954, in succession to Mr. S. G. Walter who had acted in this post since March 1952. Mr. L. R. F. D'Souza was appointed Storekeeper in July 1954.

THE PROGRESS OF RESEARCH

8. This report covers the eighteen-month period from January 1954 to June 1955. A summary of research progress has been published as a part of the Report of the E. A. Agricultural and Fisheries Research Council. This Report should be studied by those who do not wish to concern themselves with the more scientific details of the work. The sections that follow contain reports by individual research officers on progress made in the several projects with which E.A.A.F.R.O. is at present concerned.

9. Some of the work here reported has taken the form of direct team-work with officers in the territorial Departments and in other research organisations ; and much has been inspired and helped by scientific colleagues outside E.A.A.F.R.O. The Specialist Committees, where research officers meet and discuss their work, and the present facilities for travel have afforded opportunities for exchange of ideas and for joint planning that were unknown even a few years ago. The benefit to the general advance has been great.

10. A general acknowledgement is here made to all those scientific colleagues who in one way or another have contributed to the progress reported in the following pages.

THE APPLICATION OF PHYSICS TO AGRICULTURE AND FORESTRY

WATER USE OF VEGETATION

H. C. Pereira and P.H. Hosegood

11. Measurements of the water relationships of soils, plants and climate, as outlined in previous annual reports, have been continued and extended.

12. *Irrigation.* The increasing interest in irrigation, both by Government Departments and by private enterprise, has been very marked in the past 18 months, and has led to a number of requests for advice and assistance. This has emphasised the urgent need for more research in East Africa into rates of evaporation and of water use by plants.

13. A further expansion of direct experiments has therefore been undertaken in anticipation of the arrival of further staff. Unfortunately neither of the two additional soil physicists had reached Muguga by the end of the period covered by the report, although both should arrive before the end of 1955.

14. A large potential irrigation area in the Ankole district was visited in February in company with Dr. Chenery of the Uganda Department of Agriculture, and reconnaissance profiles of soil cores were taken for estimates of surface infiltration and percolation rates. Storage capacity for available moisture at different depths was estimated from moisture-tension determinations on the cores. Similar measurements were later taken on a pilot irrigation scheme at Lake Baringo in Kenya, where detailed co-operative experiments with the Hydraulic Branch of the Kenya Public Works Department and the Kenya Department of Agriculture are in progress. Similar experiments are proposed in the Sagana area of Kenya, and on the first of the F. A. O. pilot irrigation schemes on the Rufigi River in Tanganyika. It is hoped that our staff position will also permit similar co-operation in projected irrigation areas adjoining Lake Victoria when these reach the pilot scheme stage. The best chance of progress in research in this subject is afforded by such detailed co-operation with engineers and agricultural officers where crops are grown and irrigated on an adequate scale to permit useful measurements of evaporation factors.

15. Economic use of scarce and costly irrigation water may be obtained by supplementing East Africa's characteristically erratic rainfall with occasional measured applications. A co-operative experiment on these lines has been set up at the Pyrethrum Research Station at Molo. 40 electrical soil moisture gauges have been installed to assess

irrigation need, and profile sets of soil cores have been studied for quantitative assessment of water applications. Similar experiments have been planned with the Coffee Research Station at Ruiru, where field work has begun on comparative methods of application, in preparation for larger scale experiments.

16. A 10-day visit to the Sudan was undertaken to assist with investigations into evaporation losses and economy of irrigation water.

17. *Water Use of Catchment Area Vegetation.* Studies of soil-moisture storage changes under Cypress and Pine plantations, Bamboo forest and Kikuyu Grass pasture have continued, using gypsum blocks as tension indicators to detect periods when drainage has ceased in the deep subsoil at 10 ft. or 15 ft; soil sampling by drill to these depths at times indicated by the readings of replicated profile sets of blocks has given quantitative measures of water use. A new point of interest arising during the past year has been the unexpectedly high rate of water use by 6 ft. tall quick-growing indigenous weeds (mainly *Leonotis* sp.) which invaded an experimental clearing after the felling of part of a mature cypress plantation. These weeds exhausted the available water in the first six feet of soil, and used as much stored water as the remaining stand of cypress took from 10 feet. This illustrates the danger of making assumptions about the water use of vegetation, since the suspicion that forest plantations use more water than indigenous vegetation has been frequently voiced.

18. A paper on the "Water Use of Catchment-Area Vegetation" by Dr. Pereira was given at the Second Formal Hydrology Conference of East and Central African Territories, held at Victoria Falls in September 1954: visits were paid to the Sabi River Irrigation Research Station, and to the Henderson Research Station near Salisbury.

19. Where important catchment-area hillsides have been denuded of forest, one of the economic methods of return to correct land usage may be the planting of black wattle or eucalypts, provided that these are far removed from underground water tables. The water use of such species is a subject of much controversy, due particularly to the effects observed when eucalypts are planted in swamps or otherwise in contact with water tables. Studies have therefore begun on plantations on the Muguga estate. The first stage is necessarily the determination of root depth and distribution. Two pits under black wattle (*Acacia mollissima*) trees of 14-inch and 23-inch d.b.h. respectively have been opened for root-washing by a portable motor-pump. Both pits show the developed soil to be 18 feet deep over weathered trachyte. The whole soil profiles are freely permeated by vigorous roots in both

cases, some of the roots entering the weathered rock. Two adjacent trees of *Eucalyptus saligna* (d.b.h. 32 and 30) have shown similar root systems intertwining near the surface. Seasonal soil moisture changes will be measured in both plantations, for comparison with adjacent star-grass pastures.

20. At the invitation of the Tanganyika Government, Dr. Pereira joined a team undertaking a study of the Mufindi area of the Southern Highlands, in October 1954. The main problem was the effect on the tea plantation industry of the destruction by native cultivators of some 300 square miles of indigenous forest, surrounding the tea gardens. A report was drawn up recommending certain changes in land use and the organised promotion of wattle plantations as a means of restoring a tree cover, while putting unproductive and frequently burned sour-grass country under a cash crop.

21. A joint experiment with the Silviculturist has been planted to test the effects of depth of preparatory cultivation, depth of weed-control tillage, and the effects of interplanting with food crops on the establishment and growth rate of *Pinus patula*. The design is four replications of 3×2 treatments, in $\frac{1}{8}$th acre plots.

22. *Soil Moisture Storage and Depletion in Arable Rotations.* The "Dry-farming" experiments at Kongwa, Tanganyika, described in the 1953 report, have been continued in co-operation with the O.F.C. (T.A.C.). Maize, sorghum and groundnuts again used less stored soil moisture than was taken by indigenous volunteer herbage or "tumble-down fallow". Weed-free water-storage fallows were again studied both under bare soil and under a protective sowing of "Teff" (*Eragrostis abyssinica*). When heavily sown at 90 lbs. per acre in the first rotation the root range of the teff was restricted to approximately 2 feet, and the water conservation equalled that of bare fallow at the end of 7 months of very hot dry weather. In the second rotation the sowing rate was reduced to 45 lbs. per acre. The teff then exhausted the available moisture to a depth of 3 feet, and conserved only a little more than maize or sorghum. An additional experiment comparing the water use of teff at three different seeding rates has therefore been laid down in 1955 and is still in progress. Since ranching has now replaced large-scale arable cropping at Kongwa, soil-moisture observations have been made during the year by electrical resistance units under *Cenchrus ciliaris*, a most important pasture grass for this area. During a visit in 1954, evapo-transpiration experiments were designed to obtain further information on both teff and cenchrus grasses in this area. These have been constructed and operated by Mr. Brzostowski who also continued evaporation and soil

temperature observations at the Experimental Farm at Kongwa, the results being analysed at Muguga.

23. At Muguga the water-use experiments on simple rotations have made good progress. Excellent leys of star-grass (*Cynodon dactylon*) have been obtained, and have shown rapid root growth. No run off has yet occurred. Less than a year after planting this grass reduced the first 10 feet of soil to wilting point. This was indicated by the resistance blocks and confirmed by soil sampling to 10 feet on all 16 fields. Oats and beans drew their water from the first 6 feet only. A vigorous crop of oats, growing in the cooler part of the year (the long-rains crop) drew less water from the soil than that taken by a poor crop of beans in the hotter (short-rains) season. The beans eventually failed from drought.

24. These measurements offer a useful opportunity to compare "potential evapo-transpiration" with actual field use of water by grass and crops. A set of eight evapo-transpiration tanks have therefore been set up, four of them planted with star grass kept at a length comparable with that of the grazed pastures, and four planted with oats (long rains) and beans (short rains). The tanks are surrounded by areas of the appropriate crop. These tanks, constructed from 44-gallon drums in the E.A.A.F.R.O. workshops, will permit measurement of water use by the plants with a free water supply. Two of each set of tanks are watered by sprinkling, the other two being supplied by a water table maintained within the soil column.

25. The C.C.T.A. Soils Conference and the 4th International Soil Science Congress, both at Leopoldville, were attended in August 1954, at each of which papers were given on water use of plants.

26. *Restoration Experiments on Eroded Semi-Arid African Land.* Co-operation has continued with the Kenya Department of Agriculture in the field trials at Makaveti in the Machakos area. Soil-structure measurements on undisturbed cores have shown a very slow rate of improvement under grass in these hot semi-arid conditions. 280 lbs. per acre N.P.K. fertilisers, applied to split plots annually for two years, have given pasture responses in yield of grass (grazing-days per acre) on all 5 types of pasture. The effects on rainfall acceptance, percolation rates and freely-drained pore space were, however, unexpected. Only one grass, *Cenchrus ciliaris*, showed improvements in these respects, while natural "veldt" and Rhodes grass (*Chloris gayana*) pastures showed a reduction in these structural properties. The extra trampling associated with the higher grazing yields appears to be responsible for this deterioration.

27. Analysis of records of grazing, haymaking and feeding of yarded cattle have been carried out, and a progress report prepared for the first six years of these experiments. The rainfall has been highly variable, annual totals for calender years being 10, 16, 54, 22, 21, 24 inches. Even within the last three years distribution has been erratic, the two successive 12-months periods commencing with the November short rains totalling 35 and 15 inches respectively. The all-year-round carrying capacity when hay was fed in the dry season has been a little better than one adult small zebu beast per two acres of improved pasture, on half of which hay was taken annually in the long rains. Half of the 80 half-acre paddocks have therefore been stocked on this basis for further trials. The remaining 40 paddocks are being ploughed to test residual fertility and to observe the duration of structural improvements achieved under grass.

SOIL STRUCTURE STUDIES

H. C. Pereira and P. H. Hosegood

28. As a result of work completed and published during the period of this report (*J. Agric. Sci.* **45**, 401) wet sieving has been discontinued as a routine test. Dry sieving of clods, crumbs and dust has been continued only in the special tests for disintegration effects of rotary tines. Application of heavy artificial rain of controlled drop size and intensity (1 inch at 6 inches per hour) to large soil cores maintained under a constant drainage tension has proved a more satisfactory test, well worth the extra trouble. A paper giving full details of this test, with photographs of the equipment, has been accepted for publication in the *J. Soil Science*, but will not appear until 1956.

29. *Rotation Experiment at Serere, Uganda.* Structural observations on a coarse sandy loam of Basement Complex origin, which is typical of much of the cotton crop area, were made in January 1954. The complex long-term rotation experiment laid down in 1936 by the Uganda Department of Agriculture was sampled to estimate the physical changes developed in the course of three complete quinquennial cycles. Treatments involving one, two and three-year leys, both with and without grazing, were sampled. Five different criteria of soil structure were employed on each of 72 undisturbed cores.

30. In this trial the coarse pore space of the soil is produced mainly by insect activity, due largely to both soil-eating and cellulose-eating termites. Length of ley appears to affect this activity directly by provision of increasing bulk of herbage. This sandy loam caps rapidly under rainfall impact, and the capping is the most important structural change

which occurs during the rotations. Core samples in each of the treatments tested were taken both immediately before breaking, and at the ends of the first and second years of arable cropping after breaking.

31. Significant improvements from a 3-year grass rest, as compared with 1 and 2 years of grass were measured in both rainfall-acceptance and percolation-rate tests before breaking the grass. These improvements were lost so rapidly on breaking that they failed to reach statistical significance in either of the subsequent arable stages of the rotation. An important structural effect in this experiment is the adverse results of grazing the leys. Significant structural improvements brought about by ungrazed grass were halved in some treatments and completely eliminated in others when grazing occurred.

32. *Dry Farming Experiments at Kongwa.* Core-samples were taken during a visit in November 1954. The main structural changes noted were the extreme induration which occurs when this soil type is water-logged. The problem is so severe in agricultural practice that groundnuts can be harvested only when grown on the ridge. In these experiments tie-ridging was employed, the ridges being made by standard ground-nut planting equipment and tied by hand. Water lay in the tie-ridged basins and evaporated. Sampling carried out after 6 months of subsequent dry weather showed quite remarkable hardening of the soil. Using a cylindrical sampling tool, cores of 4 inches diameter and 3 inches deep were cut by blows of a 10 lb. sliding hammer, mounted on the cylinder, and falling 1 foot.The average number of blows per core were:—

On normal ridges	20
On ridges submerged by local flooding	67
In tied-ridge basins	435

33. This hardening of the soil evidently occurred late in the rains, since some of the tied-ridge plots were sown with teff grass, and the soil in the basins was freely penetrated by grass roots. The basins thus penetrated by roots consistently required more blows per core than did those under bare fallow, although the effect did not reach statistical significance. This hardening effect is largely reversible by wetting, since percolation rates averaged 3 inches per hour through cores from the basins, and 5 inches per hour from the ridges, while rainfall acceptance rates by re-wetted soil were slightly better in the basins than on the ridges.

34. *Development of Rotary Cultivation Techniques.* Continuing work done at Ruiru on the adaptation of the rotary cultivator to East African conditions (Pereira and Jones, 1954, *Emp. J. Exp. Agric.*, **22,**

323) further soil studies have been made on the continued use of the prototype machine, which is being employed by the Coffee Research Station in tillage trials in Arabica coffee. Results up to the present are most encouraging. Previous trials had shown the forked hand-hoe to be the best available implement. After a year of comparisons in a replicated field trial, the modified rotary hoe had produced a tilth equal, in all respects tested, to that of the hand hoe.

35. A paper on tilth testing methods for development of cultivation implements for African soils was read at the C.C.T.A. Conference on Mechanised Agriculture at Entebbe.

AGRICULTURAL METEOROLOGY

H. C. Pereira, P. H. Hosegood and E. Kasavuli

36. In 1955 Dr. Pereira attended the C.S.A. Specialist Committee on the Climatological Atlas of Africa, and took the opportunity to pay brief visits to Stellenbosch and Pretoria Universities. The Jonkershoek experiments in catchment-area hydrology were visited with Professor Wicht.

37. At Muguga two additional standard 5″ raingauges and one Dynes Tropical Pattern recording raingauge were set up in the terracing experiment, since although only ¼ mile from the meteorological station, differences of rainfall were expected (and were subsequently confirmed).

38. As in previous years three evaporation pans were operated at Muguga. The U.S.A. Weather Bureau pattern of raised pan was used with a heavy grid cover to conform with the Kenya P.W.D. practice, since the latter organisation has the only substantial number of evaporation pans. The second pan, installed by the method used in all E.A.A.F.R.O. studies, is a Weather Bureau pan, sunken to protect the sides from sunlight, but insulated by an air gap from the diurnal temperature fluctuations of the soil. It rests on timber bearers in a pit revetted with a hoop of corrugated iron, the two-inch air gap being closed by a wooden cover. This arrangement permits easy routine lifting, inspection, and repainting of the pan. The third pan is the standard Australian "Trumble pattern" tank, 3 feet deep and 3 feet in diameter, surrounded by a 6 inch guard-ring of water contained in an outer 4 feet diameter tank. This is sunken in a revetted pit as for the Weather Bureau model. Maximum thermometers are installed near the surface and the bottom of each pan. A fourth pan has recently been set up. This is identical with the second type but is connected by a 1-inch pipe to a small float chamber over which a louvred screen houses a water-level recording drum and a thermograph connected to a bulb in the tank. The level

recorder will enable splash losses on days of heavy rain to be assessed more accurately. The results from a similar device set up by the Namulonge Cotton Research Station have indicated the substantial errors caused by neglecting such splash losses from evaporation tanks in East African conditions.

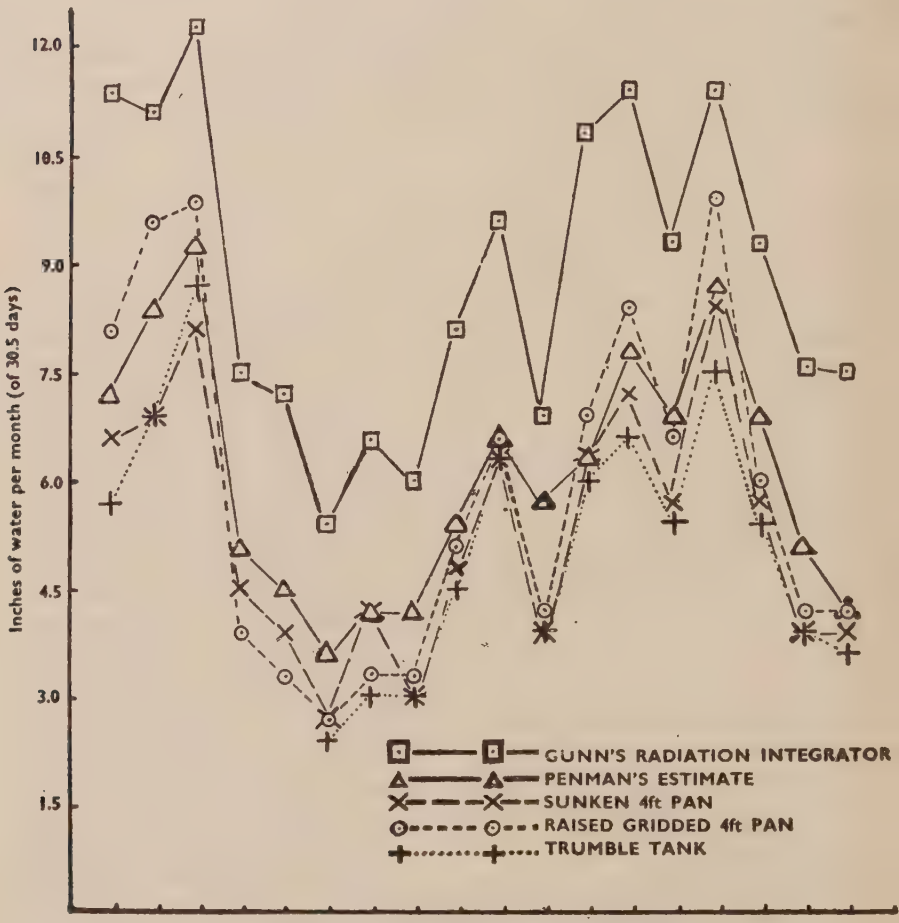

FIGURE 1 EVAPORATION COMPARISONS

39. The Gunn, Kirk and Waterhouse improved version of the simple Bellani distillation type of radiation integrator continues to give a surprisingly good estimate of the pan evaporation. Figure 1 illustrates monthly mean readings for the period of this report. The raised pan, with grid cover, agrees well with both types of sunken pan

when evaporation is low, but gives an exaggerated estimate in hot weather. The Weather Bureau pan, when installed in the E.A.A.F.R.O. manner, agrees closely with the results of the more elaborate Australian pan. The Gunn radiation integrator can clearly give a useful approximation to the pan records, while avoiding the many difficulties, particularly during the dry season, of operating an open-water pan in East Africa. Equally satisfactory results have been obtained in previous years at two lower altitudes under hotter conditions. Unfortunately, only the single prototype instrument exists. Attempts to persuade scientific equipment manufacturers to produce it have hitherto failed, on the grounds that the instrument is too little known to be in commercial demand. A number of these instruments are now to be built by contract, since they can make a useful contribution to practical problems of hydrology and irrigation control in East Africa. Requests for additional instruments by readers of this Report will be welcomed as tending to reduce the costs of production. A full description is given in papers by Gunn, Kirk and Waterhouse, 1954, *J. Exp. Biol.*, **22,** 1, and by Gunn and Yeo, 1951, *Quart. J. Roy Met. Soc.*, **78,** 293.

SUMMARY OF METEOROLOGICAL OBSERVATIONS AT MUGUGA — 1954

	Rainfall	Air Temperature			Air Humidity		Windspeed	Sunshine	Open Water evaporation		
		Monthly Means of Daily Values							Monthly Totals		
	Monthly Totals	Maximum	Minimum	Mean	Saturation Deficit Mean of 0830 and 1600 Hrs.	R.H. at 1600 Hrs.	Mean Wind Speed at 6ft. above Ground	Mean Daily Sunshine Hours	Sunken Pan Insulated from Soil	Australian Pattern 3ft. Deep Sunken Tank	Raised Pan with Heavy Grid Cover
	Inches.	°F	°F	°F	mm. of Mercury	%	m.p.h.	hrs.	Inches	Inches	Inches
JAN.	3.65	75.4	51.5	63.4	5.56	43	6.0	9.1	6.82	5.89	8.37
FEB.	2.81	75.6	53.6	64.6	6.47	37	8.2	10.2	6.44	6.44	8.96
MAR.	0.59	76.1	54.7	65.4	6.21	41	9.2	9.6	8.37	8.99	10.23
APR.	19.52	69.6	55.2	62.5	2.58	75	5.2	5.5	4.50	*	3.90
MAY	10.55	67.7	53.8	60.8	1.87	77	4.1	5.7	4.03	*	3.41
JUNE	3.90	64.0	50.1	57.1	1.23	80	3.5	3.5	2.70	2.40	2.70
JULY	1.79	64.4	48.4	56.4	1.67	72	3.7	4.8	3.41	3.10	3.41
AUG.	0.49	64.0	48.5	56.3	1.91	69	4.2	4.4	3.10	3.10	3.41
SEPT.	0.14	68.0	50.2	59.1	3.25	57	5.4	6.6	4.80	4.50	5.10
OCT.	0.47	70.5	52.3	61.4	4.21	50	7.3	8.4	6.51	6.51	6.82
NOV.	2.79	67.7	53.5	60.6	2.95	68	8.7	6.6	3.90	3.90	4.20
DEC.	0.70	70.9	52.0	61.5	4.02	54	7.6	9.0	6.51	6.20	7.13
Annual Totals ..	47.40	—	—	—	—	—	—	—	61.09	—	67.64
Annual Means ..	—	69.5	52.0	60.8	3.49	60	6.1	7.0	—	—	—

(For notes on this table see report on Agricultural Meteorology.)

* No records; Tank rebuilt.

RAINFALL AND CROP YIELD

RAINFALL RELIABILITY

J. Glover and P. Robinson

40. Of the main climatic factors concerned with plant growth in East Africa, rainfall is the one subject to the most violent fluctuations. As mentioned in earlier reports (1951—53) a simple method of measuring and mapping the reliability of rainfall has been developed. The details have been published in various journals (see list of publications).

41. The maps of reliability of annual rainfall presented to the East Africa Royal Commission 1953—55 were accepted and published. They were used as base maps to illustrate various aspects of the Report and were referred to on numerous occasions. In particular they supplied the foundation of the Commission's discussion of agricultural potential.

42. A large-scale map of the reliability of rainfall in the Kenya Highlands was used by Mr. L. G. Troup in his report on the General Economy of Farming in the Highlands. Its main purpose was to illustrate the connection between reliability of rainfall and the distribution of different types of farming.

43. Since most of the annual total rainfall in East Africa falls in well-defined seasons and annual crops such as cereals depend on the seasonal rainfall, the need for maps of the reliability of seasonal rainfall is self-evident. Maps of this nature have been completed for Tanganyika and the corresponding maps for Uganda have been started. Those for Kenya remain to be done. Progress of this work is slow due to the large bulk of data that must be extracted.

RAINFALL AS A CONTROLLING FACTOR IN YIELD OF MAIZE

J. Glover

44. When the rainfall reliability maps were in preparation, it was observed that maize was being grown in regions of unreliable rainfall where there were well-marked alternating wet and dry seasons each of several months duration. It was realised that such conditions might provide an opportunity of studying yield/rainfall relationships. The area with the most suitable records for this purpose proved to be the west-Rift area of the Kenya Highlands. The many European farmers in this area report acreage planted with maize and its yield to the Board of Agriculture, Kenya, who in turn publish the statistics. As the area

is divided into sub-districts, which range in size from one or two farms with only a few hundred acres of maize to a closely knit group of farms which together grow several thousands of acres, it is possible to obtain average yields from small areas although it is not possible to obtain them for individual farms. Rainfall is reported to the Meteorological Department, so rainfall records for the sub-districts are also obtainable. It is thus possible to study a series of yields and rainfall over a period of years. As yield records have only been published since 1943 only eleven years, records were available.

45. The west-Rift area is a compact high-altitude plateau. Most farms lie in a block about 100 miles long and 50 miles wide. Most maize farms lie between 6,000 and 7,000 feet a.s.l. The growing season is from April-October, which includes the long rainy season. At this time temperatures and insolation vary little throughout the area. The only aspect of weather which shows major differences from place to place is rainfall.

46. *Results.* In the drier regions increasing rainfall increased yield and the linear regression of yield on seasonal rainfall was highly significant. There was, however, a hint of curvature in the records indicating that the relationship was not truly linear.

47. In the wetter areas increasing seasonal rainfall decreased yield and again the linear regression of yield was highly significant. Once more there was a hint of curvature in the records and this appeared to be equal and opposite to that encountered in the drier areas.

48. Further investigation showed that a curve of the form $Y=A_x^b e^{-ax}$ where Y is yield, x is rainfall and A, b and a are constants, fitted the records from all parts of the area. When used to estimate yield it gave better results than those from the linear regressions and in particular gave a very marked improvement in estimates when extremes of rainfall were encountered.

49. At this stage it was realised that the curve relationship might account for the remarkable constancy of the overall (weighted) mean yield from the west-Rift area. Although acreage had increased by 50% from 1943, and although rainfall could vary by more than 50% in successive seasons, there has been no reflection of this in the overall mean yield which has remained nearly constant for the past eleven years; varying only between 6.6 and 7.9 bags/acre. It is known that if a wet season occurs in one district it is common to the others and if a dry season occurs in one part it is also dry in others. The constant overall mean yield could therefore be accounted for if the acreages under maize were reasonably equally distributed in wet and dry regions. In a dry year the farms in a dry region would have poor yields but the farms in a wet

region would have good yields. In a wet year the opposite would happen. The overall result would be a remarkably constant overall mean from the whole of the area.

50. It is impossible to judge objectively the dividing line between dry and wet regions, for there are many gradations between them and so it is impossible to judge whether farms are actually distributed as theory requires. However a study of the distribution of rainfall and acreage in each district leads to the conclusion that the acreage in the whole region is distributed between dry, indeterminate and wet zones in the proportion 100 dry: 57 indeterminate and 95 wet. This indication of reasonable equality of distribution in the different zones is reinforced by the following consideration. If the curve relationship holds good over the whole area and if the farms are distributed at random in the dry and wet areas, then the estimates of yield from any two sub-districts of reasonably equal fertility but of different rainfall regimes—one normally too dry, the other normally too wet—should be intimately related to the overall mean yield. Two such sub-districts were found. As the curve is roughly symmetrical about the Y-axis the regression of overall mean yield on the simple arithmetic mean of the estimate in each year for each sub-district was calculated. The regression was very highly significant, so there is therefore a strong suggestion that the farms in the west-Rift area are indeed reasonably equally distributed over the range of rainfall suited to the cultivation of maize in this region.

51. The comparison between actual yield and the estimate based on the curve are shown in the Table.

ESTIMATE AND OVERALL MEAN YIELD IN THE WEST-RIFT AREA 1943—1953

200 lb. bags of maize per acre.

Year	Actual	Estimate
1943	6.9	6.9
1944	7.1	7.0
1945	7.4	7.4
1946	7.2	7.1
1947	6.6	6.6
1948	7.8	7.7
1949	7.9	7.7
1950	7.8	7.7
1951	7.8	7.7
1952	6.6	6.4
1953	6.8	7.0
Mean	7.2	7.2

52. The estimate, which is based only on the seasonal rainfall in two sub-districts, is remarkably close to the actual yield and is even closer than if the mean only were used as an estimate of such constant values.

53. The potential value of the curve in forecasting overall mean yield as well as sub-district yield is obvious.

54. Another aspect of this curve relationship is its bearing on fertiliser programmes. The curve indicates that yield is a product of the interaction between rainfall and soil fertility. The usual method of judging the effect of fertilisers is to measure changes in yield and to ascribe such changes to the fertiliser. Since, in the Kenya Highlands at least, the interaction determines yield, the changes in yield must also in some part be due to the moisture status of the plant. It seems essential therefore to include both factors, water and fertiliser, in any experimental study of fertiliser requirement in this region.

THE NUTRIENT STATUS OF EAST AFRICAN SOILS

H. F. Birch

55. Soil and plant samples have been received from most of the 1954 field trials carried out by officers of Departments of Agriculture. The analyses of these are not yet complete. From the data so far available soil fertility, as shown by yield, has been found to be significantly related to the following soil chemical properties, total exchangeable bases (T.E.B.), base exchange capacity (B.E.C.), degree of base saturation and amount of water-soluble silica. These measurements are related to the amount of available phosphate in the soil, lack of which is one of the main fertility factors governing yield in East Africa. There was no evidence that yield, in these experiments, was directly governed by the base status of the soils.

56. The silica and exchangeable base values also reflect other soil properties governing fertility. For example, a soil with a low B.E.C. (sandy soils excluded) indicates a kaolinitic type of soil with good drainage, while one with a high B.E.C. indicates a montmorillonitic type with poor drainage. It was therefore considered that clay-mineral analyses of the soils might serve as a somewhat better measure of soil fertility, on the grounds that such data would be more closely related not only to phosphate availability and drainage but also to the environmental conditions under which the different clay types are formed. To test this hypothesis 31 soils from the 1950 Highland Fertiliser Scheme wheat trials were analysed for the kaolinite, montmorillonite and illite contents of their clays and for their silica: sesquioxide ratios. The results showed that, when the soils were grouped on a clay-mineral basis, the more montmorillonitic group showed somewhat higher yields than the more kaolinitic groups; but the variation of yield between groups was less than that within groups, in which yield depended significantly and directly on the B.E.C., T.E.B., and water-soluble silica contents of the soils. The base and silica measurements are more closely related to yield than are the clay-mineral data and are more readily determined. The clay-mineral work, however, was of interest since it revealed some interesting soil-clay relationships which are described in the next section.

57. Since soil fertility, as reflected in yield, is governed by a number of factors, which include both the physical and chemical properties of the soil as well as climate, it is obvious that chemical methods for assessing soil fertility are of limited value. A complete assessment of the value of such methods for East African soils can only be made when data for all the trials, including plant analyses, are available. It is already clear,

however, that chemical methods for assessing soil fertility must take into account climatic and soil physical factors.

58. *Soil-Clay Relationships.* Arising from the work described above it has been found that the amount of water-soluble silica in the soil, particularly when expressed as

$$\frac{\text{water-soluble silica} \times 100,}{\%\ \text{clay in soil}}$$

is very significantly and directly related to the $SiO_2 : R_2O_3$ ratio of the clay, and very significantly and inversely related to the kaolinite content of the clay. It was also found to be significantly and directly related to the T.E.B. content and B.E.C. of the soil. From these results, and work in progress using authentic clay minerals, it is apparent that the amount of silica extracted depends mainly on the kinds and amounts of clay minerals present in the soil. The highest values were obtained with montmorillonite and montmorillonitic soils, and the lowest with kaolin and kaolinitic soils.

59. These relationships, together with that between phosphate response and water-soluble silica described in a previous report (1952), show the value of water-soluble silica determinations in both soil-fertility and soil-classification studies. After further work on extraction methods and on the significance of the amount of silica extracted, it is intended to include water-soluble silica determinations as a standard procedure in soil studies.

60. *Soil Organic Matter and Nitrogen.* The object of this work was twofold; first, to determine the general organic-matter and nitrogen status of East African soils and the factors on which it depends, and, second, to relate this information to the results of fertiliser trials with nitrogen.

61. Generally speaking the organic-matter and nitrogen contents of the soils proved to be fairly high and compared favourably with the the amounts in temperate soils. This is particularly true for soils in the Kenya Highlands. The amounts of organic matter and nitrogen were found to depend primarily on rainfall and to a less extent on the clay content of the soil. The effect of temperature, within the range encountered in these studies (54—80°F), appeared to be negligible. The regression of total nitrogen in the soil (surface 12″) on rainfall, namely, % N=0.00665 in. rain—0.061, was very significant ($P<0.001$) and compared closely with similar regressions for two groups of soils in Nebraska and the Middle West. What still has to be decided is whether the organic matter once incorporated with the soil is relatively resistant to further

breakdown, or whether rapid loss is offset, under natural conditions, by rapid addition of plant residues. These alternatives will be investigated.

62. The high organic-matter and nitrogen contents of the soils in the Kenya Highlands are in agreement with the generally poor response to nitrogen shown there. The only area in the Highlands where nitrogen responses are generally obtained, namely in the Uasin Gishu and Trans Nzoia districts, corresponds with relatively low organic-matter and nitrogen contents, possibly as a result of continued cultivation, burning and the shallow nature of the soils. These studies indicate that conservation of the present organic-matter and nitrogen status of the better soils of the Kenya Highlands should be aimed at in order to prevent deterioration of the soils to a stage where applied nitrogen is necessary. They also form a useful basis on which to plan more specialised work, chemical and microbiological, on soil organic matter and nitrogen.

THE EFFECTS OF TERMITES ON SOIL

P. R. Hesse

63. *The Base Exchange Capacities of the soils of mounds built by Macrotermes sp.* Previous work has shown that sometimes the base exchange capacity (B.E.C.) and the total exchangeable base (T.E.B.) content of a termite mound soil are higher than those of the adjacent sub-soil. It was also shown that these differences are not due to increased amounts of clay or organic matter, the presence of fungus comb or the presence of termite bodies.

64. Further work has confirmed that in most cases no difference in B.E.C. or T.E.B. contents occurs between a mound soil and its adjacent sub-soil. However, when considerable amounts of iron are present in the clay fraction, then the B.E.C. of a mound tends to be higher than that of the nearby sub-soil. The clay fractions of several mound soils and the corresponding adjacent sub-soils were separated and their B.E.C. determined before and after removal of sesquioxides. Some typical results are given in the following table.

Origin of clay	$\%R_2O_3$	B.E.C.	
		Normal	Sesquioxide-free
Mound	4.9	18.1	12.5
Sub-soil	5.2	10.5	12.5
Mound	8.7	56.5	50.3
Sub-soil	8.3	30.2	48.2
Mound	7.2	33.9	27.1
Sub-soil	7.6	22.2	26.7
Mound	1.0	59.0	40.2
Sub-soil	1.0	59.0	40.2
Mound	0.4	17.9	19.3
Sub-soil	1.0	17.0	19.3

65. The results indicate that where a difference in B.E.C. between a mound and nearby sub-soil occurs, it is due to the displacement of sesquioxides from the clay lattice. This may conceivably take place when the clay is chewed by the insects. That the sesquioxides are merely displaced and not removed is shown by the fact that their content in a mound soil is the same as in the corresponding, adjacent sub-soil.

66. *Cubitermes sp.* This genus is responsible for the low, dome-shaped mounds so common in the Eldoret—Londiani districts of Kenya. They normally occur in large numbers and are built approximately two yards apart.

67. As far as their effect on soil is concerned, *Cubitermes* differ from *Macrotermes* in that they build with soil which has passed through their bodies, whereas *Macrotermes* merely carry the soil particles. Consequently it may be expected that *Cubitermes* will affect the chemical nature of the soil—an effect not caused by *Macrotermes.*

68. A study of *Cubitermes* mounds between Londiani and Eldoret was made in conjunction with the Termite Research Unit, and about two hundred soil samples collected. Following the procedure developed for the *Macrotermes* study, soil from inhabited and nearby uninhabited mounds was collected as well as from the adjacent soils.

69. Preliminary analyses have shown that *Cubitermes* do not affect the pH of a soil, nor its mechanical composition. The mound-soils however, contained more carbon and nitrogen than did the surrounding soils. In every case the inhabited mounds contained more C and N than did the uninhabited.

70. It has been suggested by Mr. W. V. Harris that the observed increase in organic matter may be due to lignin which termites are unable to digest. This material would remain in the mound however many times the insects redigest each other's excrement.

SULPHUR IN SOIL AND WATER

P. R. Hesse

71. Sulphur is an important plant nutrient because it is essential for the formation of protein. It also affects the formation of chlorophyll, the availability of other nutrients (by lowering the pH of a soil) and the rate of nitrogen fixation by legumes. Sulphur has been found to be a beneficial fertiliser for tobacco, tea, cereals, cotton and legumes, all of which are crops of economic importance in East Africa. Thus, in view of the agricultural importance of sulphur and the almost complete lack of data concerning the sulphur status of East African soils, a series of studies has been undertaken to determine the distribution of the element in the main soil types of the country.

72. As a first step in the investigation, work was confined to perfecting methods of measuring sulphur in its various forms in soils, plants and waters. Four forms of sulphur are being measured, sulphate-sulphur, organic-sulphur, sulphide-sulphur and total-sulphur. Sulphate-sulphur measurements have been completed for a considerable number of soils widely distributed throughout East Africa and have shown that except for certain well-defined areas the soils contain little or no sulphate. Areas in which sulphates have been found in quantities greater than fifty parts per million of sulphur are the arid regions of the Northern Frontier Province, certain low-lying areas with impeded drainage, the saline deposits around salt lakes, and forest soils. It is not suggested at this stage that the soils of East Africa are deficient in sulphur, because the measurements of organic and total sulphur are yet to be completed. The few figures obtained to date show that some of the sulphate-deficient soils have appreciable amounts of organic-sulphur, which may be slowly oxidised by bacteria to sulphate in quantities sufficient for vegetation needs.

73. The distribution of sulphur in forest soils has proved to follow a definite pattern. Sulphate-sulphur is usually absent in the top-soils

but appears at a depth of approximately two feet. Total-sulphur on the other hand is present throughout the profile. Organic-sulphur in contrast to sulphate-sulphur is present in greatest amount in the upper layers of the soil and decreases with depth. In the topsoil the organic-sulphur more or less accounts for the total sulphur, whereas in the deep soil most of the sulphur is present as sulphate.

74. This pattern appears to be a general one for forest soils, varying only in the quantities of sulphur present. It seems that forests have an ideal system of sulphur conservation. The humus-rich topsoils have their high content of organic-sulphur oxidised by bacteria to sulphate, which in such regions of high rainfall is rapidly leached into the sub-soil. From the sub-soil the deep-rooted forest trees remove the sulphate, biologically reconvert it to organic-sulphur and return it to the soil as leaf litter. As might be expected, there is a rough correlation between organic-sulphur and organic matter.

75. *The distribution of sulphur in the water, muds and vegetation of Lake Victoria.* It has been demonstrated in the laboratories of the East African Fisheries Research Organisation that a shortage of sulphate in the lake water is controlling the growth of phytoplankton. As phytoplankton is the main source of nutrients for *Tilapia* sp.—the fish of greatest economic value — this apparent sulphate deficiency is a problem of primary importance.

76. Owing to the fact that sulphate is removed from the water by biological precipitation in the form of animal and plant remains, it was thought that the sulphate ultimately becomes anaerobically reduced to insoluble and unavailable sulphides which accumulate in the mud of the lake bed. Thus, although the water is deficient in sulphur, the element may well be present in large quantities at the bottom of the lake.

77. In conjunction with the Fisheries Research Organisation, a preliminary investigation of the sulphur balance in the lake has been started. Work has so far been limited to the small, northern area around Jinja. The results have shown that sulphate is completely absent at all depths from the lake water and total sulphur is present to the extent of only one to two parts per million. The analyses of mud profiles have revealed that sulphur is present in abundance but not, as expected, in the reduced form of sulphide. The main part of the sulphur was present in the organic form. The comparatively high values of sulphate-sulphur (about 500 p.p.m.) in the muds, even at depths of twenty feet, together with high redox potentials and presence of ferric iron, seems to indicate that anaerobic conditions do not exist to any great extent at the lake bottom.

78. A further point arising from the results is that although the surface muds are rich in sulphate the water immediately above them is practically devoid of the salt. Typical figures are 700 p.p.m. SO_4—S in the mud and 1 p.p.m. SO_4—S in the water. As a tentative hypothesis it is suggested that the sulphate ion is strongly adsorbed on the mud surface, probably by a colloidal complex. Such a complex would be destroyed by either acidification or by reduction and would then liberate the adsorbed ions. Thus in the laboratory the sulphate is liberated by the acid-extracting solution, whereas in the lake the neutral or slightly alkaline water cannot remove the ion.

79. Analyses of vegetation growing in the lake have shown that the higher plants are rich in nutrients. The average total sulphur content of under-water plants is about 0.1%, a value equivalent to that for wheat and grass. With respect to other elements the plants are comparable with our richest grasses. Papyrus, too, contained considerable amounts of sulphur, the contents being approximately 0.1% in the roots, 0.03% in the stem and 0.06% in the head. Three samples of phytoplankton were analysed and it was found that although one sample consisting of about 60% diatoms contained 0.2% sulphur, another consisting of 85% diatoms contained only 0.02% sulphur.

ANALYTICAL SERVICES—CHEMICAL

M.T. Friend

80. This section has been mainly occupied in providing analytical data for other officers to assist in their research. The flow of samples has been large and has required concentration on routine analyses and permitted little independent research.

81. In all 11,174 determinations were carried out on 1,491 samples. These numbers were made up primarily of the following:—

Fertiliser Schemes. 505 soils were analysed for pH, carbon, nitrogen, sand, silt, clay, water-soluble silica and three forms of phosphate, from fertiliser trials in Kenya and Tanganyika.

Soil Survey. 316 soils were analysed for pH, nitrogen, carbon, sand, silt, clay and water-soluble silica.

Ecological Survey. 53 detailed clay and soil analyses.

Plant Analyses. 91 plant samples were analysed for various constituents including carbohydrate, protein, phosphorus and copper.

Miscellaneous Analyses. 26 soils were analysed for the Soil Physics Section and 20 for a soil fertility investigation on the farm at Muguga. 9 fertilisers were analysed for N.P. and K.; and 48 muds from Lake Victoria for iron and silica.

82. *Wheat Investigation.* To determine whether the different dough strengths of flour from the same variety of wheat were due to

soil differences, a trial was laid down by the Senior Plant Breeder at Njoro. This involved 10 varieties of wheat with 12 replications of each. 120 top soils and 120 sub-soils were analysed by E.A.A.F.R.O. for pH, carbon, nitrogen and sulphur. The uniformity of the analyses indicated that in this instance at least dough strength was not related to soil properties. This work on the factor responsible for the decline in dough strength of flour from certain varieties of wheat is being continued in conjunction with the Senior Plant Breeder, Njoro, the Chief Chemist at Unga Ltd., and the Spectrochemical Section of E.A.A.F.R.O.

83. *Advisory Work.* 15 soil samples from the Northern Province Stock Farm, Tanganyika, were analysed for the Livestock Officer to help in planning a manuring programme. The results confirmed his impression that the organic-matter and nitrogen contents of the soils were low.

ANALYTICAL SERVICES—SPECTROCHEMICAL

G. T. Chamberlain

84. The Lundegardh flame method has been in use throughout the period except for six months pending the arrival of new assistant; and Mr. Friend spent two months with the section to deal with the base determinations on urgent samples. In spite of the interruption in the flow of work, a total of 1,265 samples have been analysed for bases, details being given below. Analysis with the arc methods using the Littrow spectrograph has progressed to the stage that problems involving suspected trace-element deficiencies are now being investigated.

85. A new development in the laboratory has been the building of a "triggered-arc" circuit, originally devised by the British Non-Ferrous Metals Research Association. It is intended to use this source as means of obtaining better accuracy or sensitivity with elements that are either too volatile or insensitive in the normal arc or flame sources.

86. *Flame Analysis.* One of the primary tasks has been to analyse a large number of soil and plant samples, mostly for content of calcium, magnesium, potassium, sodium, and manganese. Nearly half of the soil analyses were in connection with the researches of other E.A.A.F.R.O. officers; for the soil survey and ecology sections to assist in characterising the soil samples collected by them; and for research on the fertility of East African soils. A large number of the analyses were of samples of soils from fertiliser experiments conducted by the Kenya and Tanganyika Departments of Agriculture, to be used for relating the chemical constituents of soils with the responses of these soils to added fertilisers; and for many of these experiments parallel analyses were made of the

maize and sorghum on them. In certain experiments in Tanganyika it was found that treatment with phosphatic fertilisers had significantly reduced the calcium and potassium uptake of the plants. Soil analyses for the Northern Province Stock Farm of the Tanganyika Veterinary Department assisted those in charge in planning the use of the land. A number of analyses of feeding-stuffs were carried out to assist in the Animal Industry Division's nutrition studies, and to provide general information on the mineral content of animal feeding-stuffs in general use in East Africa.

87. At the request of the Tanganyika Agricultural Corporation, samples from various parts of the groundnut plant—leaves, stems, roots, kernels and shells—were analysed, as part of a study with Mr. B. Anderson of the changes in the composition of the plant in the course of its development.

88. On behalf of the Kenya Coffee Research Station, samples of elephant grass (*Pennisetum purpureum*) and coffee leaves were examined. These demonstrated an unexpectedly high annual removal of potassium from the land when this grass species was cut and used for mulching coffee. As an outcome the Coffee Research Station established new fertiliser trials with elephant grass.

89. Spectrochemical analyses for calcium, magnesium and potassium were carried out on a large number of solutions resulting from Dr. Birch's studies of the clays of East African soils.

90. *Arc Analysis.* The three arc methods outlines in last year's Annual Report have been brought into full working order and the copper-iron-manganese method extended to include calcium (1—30%), magnesium (0.06—12%) and sodium (0.08—15%). Evaluation of intensity ratios using Seidel densities has been adopted and a calculating board made for this.

91. Copper determinations were carried out on six samples for the Specialist Committee for Animal Industry, in connection with the programme for devising standard analytical methods. The spectrochemical figure showed a tendency to be a little higher than the chemical figures submitted by other co-operating laboratories. Eighteen animal feeding-stuffs were analysed for the trace elements copper, manganese, iron, strontium, barium, chromium, cobalt, nickel, zinc, titanium, silver, molybdenum, vanadium, gallium, tin and lead, and it is believed that these data are the first to be obtained for East African materials. Fifteen of the samples were the commercially available products, the remainder being grown on the Muguga Farm. Comparisons were made where possible with the values for similar feeding-stuffs reported by workers

in other countries. The East African values are generally of the same order as those reported elsewhere; but some divergencies are found. Thus, for molybdenum, higher values for barley (5 p.p.m.), oats (2 and 9 p.p.m.) and maize (8 p.p.m.) have been reported in American materials compared with 0.7, 0.7 and 1 p.p.m. respectively for the East African feeding-stuffs. On the other hand, as much as 300 p.p.m. molybdenum and 6900 p.p.m. manganese were found in the lupin sample.

92. Full details of the results are being published and it is intended to expand the work to a wider range of feeding-stuffs.

93. In connection with a co-operative study of the dough strengths of Kenya flour, six samples of flour from two varieties of wheat, No. 184 and "Kenya Settler", were analysed for Messrs. Unga Limited. This was an exploratory test; and preliminary results suggested that some relation might exist between the contents of manganese and barium and dough strength. Further work is being undertaken to see if this can be confirmed.

94. For the Tea Research Institute, Kenya, trace elements were determined on three tea samples, to investigate whether any of these elements might be concerned with the failure of certain pickings to ferment. Preliminary results indicated that the concentrations of manganese, lead, tin and nickel changed systematically with fermenting properties; but more analytical work is to be carried out in order to confirm or refute these indications.

95. *Advisory Work.* At the request of the Uganda Development Corporation, Mr. P. F. Shilton visited Muguga twice in order to see the work being done and to familiarise himself with the arc techniques, and particularly the methods of evaluation. I visited Mr. Shilton's laboratory in April 1954, and corrected a fault in the spectrograph and assisted in establishing an arc method for the determination of Mo, Ni, V, Cr, Co, and Ti, in an alumina-silica base. Assistance was also given to Dr. Foy of the Wellcome Foundation in the use of a spectrophotometer.

96. Whilst on vacation leave opportunity was taken of becoming familiar with some of the latest developments in spectrochemistry. Visits were made to the spectrochemical laboratories of the Vatican, the Macaulay Institute for Soil Research, Rothamsted Experimental Station, Metropolitan Police Laboratories, Johnson Matthey Limited, James Booth and Company Limited and Guest, Keen and Nettlefolds Limited. Also visits were made to the equipment manufacturers, A. Hilger Limited, W. G. Edwards Limited, Baird and Tatlock Limited, Philip Harris Limited, and also to the British representative of the Applied Research Laboratories Inc. Amongst the wide variety of equipment seen were

the Quantometer by A.R.L., a direct reading spectrometer by Radio-Cinema et Cie and the "Respektra" calculating unit. Defects which had been discovered in equipment received in East Africa were discussed. A report on the visits and items of interest was circulated to interested persons in East Africa.

SOIL SURVEY

G. H. Gethin Jones and R. M. Scott

97. In March G. H. Gethin Jones attended the 1954 Kampala Scientific Conference and gave a paper on "The Development of Natural Resources for Food Production". He also prepared a paper entitled "The Value and Limitations of Soil Survey", which was read on his behalf at the 1954 C.C.T.A. African Soils Conference. In September a group of pedologists who had been attending soil conferences at Leopoldville visited Muguga. Mr. Scott conducted three pedological excursions through parts of the Kenya Highlands and another through semi-arid regions with pedocal soils and on to Arusha in Tanganyika. The participants included Messrs A. Muir and G. V. Jacks from the United Kingdom, G. A. Stewart from Australia, and J. D'Hoore, Director of the Inter-African Pedological Service.

98. *Soil Classification.* With a build-up of representative soil profiles, which now total about 450, and of the accompanying mass of morphological data about different kinds of soil noted and collected during field surveys in different parts of East Africa, and also the accumulation of many analytical data, it has become possible to make a further re-sorting and extension of a first system of soil classification. Though it is appreciated that there is a lack of essential comparative morphological and chemical data, and that there is as yet no recognised uniform basis for classifying and naming tropical soils, it is considered that the time has come to make a start on a first classification of regional soils. With a suggested grouping in being, it is possible to sort out soils already recognised, and new kinds noted can more readily be placed within an expanding framework. The classification which has been made is tentative and mainly for the purpose of correlative work with fellow pedologists. An intermediate category of classification between Great Soil Groups and Soil Series has been allowed for.

99. Soil surveys which have formed the basis of classification have been carried out at different levels of detail and scale according to the immediate objective of particular surveys. Exploratory surveys have been made over much of Kenya and Uganda and to a smaller extent

in Tanganyika. Some detailed reconnaissance work has been done in the latter two territories, but the greatest amount of information about soils and their distribution is based on field work in Kenya. This has covered a wide range of geological, topographical and climatic conditions at elevations ranging from sea-level to 10,000 feet. Except at the Coast, there have been available 1:50,000 maps and, in most cases, also the parent aerial photographs. There have been reconnaissance surveys along roads and tracks without mapping, other than indicating the main soil boundaries crossed by the routes taken. Much of this work was carried out in conjunction with the Soil Chemist of the Kenya Department of Agriculture. It showed the kinds of soil that occur and indicated their relative extent.

100. On the same scale, there has also been complete soil mapping at about the level of Soil Families (or Associations)—and occasionally Soil Series—over a total area of about 850 square miles. Detailed, large-scale surveys of small representative areas have been helpful in clarifying the genetic relationships of adjoining soils and in expediting the survey of lands with a similar pattern of soil distribution. During all manners of survey, representative profile samples were taken, and the later comparative study of these in the laboratory has been most helpful in the sorting out and grouping of soil classes. Mechanical and chemical analyses have been useful in confirming certain soil groupings and in separating others, but the main use made of such laboratory data has been to characterise soil units established in the field.

101. The first system of soil classification and nomenclature allows for twelve Soil sub-Orders, twenty-seven Great Soil Groups, fifty-five Soil Families and about a hundred Soil Series and gives brief descriptions of the separate Soil Families. As such, it occupies too much space and is perhaps also unsuitable for inclusion in an Annual Report. A summary has been prepared giving a list of the Great Soil Groups suggested for soils noted in East Africa. This appears as an Appendix. It is hoped that the more detailed classification will be published elsewhere.

102. As a necessary corollary to soil classification, a Soil Map of East Africa on a scale of 1:2,000,000—following the Provisional Soil Map compiled by the late G. Milne in 1935—is gradually being built up. In the case of such a small-scale map, there is need to map large areas as catenary and non-catenary complexes.

103. *General Surveys.* During the period under review complete soil mapping at the Soil Family level—and occasionally as Soil Series—on a scale of 1:50,000 has been continued, mainly in the region between Nairobi and the Ngong Hills. To the north-east of Nairobi there is

a broad, intermediate zone of shallow soils over either rock or massive 'murram' on the gentle slopes, separating the deep, ferrallitic soils of the higher lands from the cracking black clays of the plains. However, westwards, the black clay derived from similar volcanic parent materials extends up the gentle slopes. At the higher elevations with more rainfall, the frequent presence of calcium carbonate at the base of the black clay ceases and, locally, an earthy, black pisolitic 'murram' formation occurs at the junction with the weathering rock. An interesting feature of the heavy soils is the occasional presence of a soil horizon of a low-density, light grey, silt loam, similar to that found on the Kinangop. It occurs either at the surface or else under a few inches of a later deposited material. The sharply defined, light grey horizon usually lies horizontal over the black clay, but locally the base of a later truncated grey material conforms with a sharply domed underlying clay, thus indicating a relic "gilgai" formation. Aerial photographs were most helpful in delineating the tree and bush-covered, slightly elevated, highly coloured soils from the wettish, heavy, grassland soils, but did not aid the separation of the component soils found within the bottom lands.

104. The most extensive Soil Families delineated comprise the following. Friable, reddish-brown (or chocolate), deep ferrallitic soils derived from trachyte and basalt; red to dark red similar soils derived separately from trachyte, tuff and phonolite or else from gneiss; orange-brown, more leached, ferrallitic soils derived separately from quartz trachyte and tuff or else gneiss; yellow-brown, highly leached, ferrallitic soils formed on ancient sandy 'mantle' material in metamorphic country; shallow, brownish-red soils overlying earthy fragmentary ironstone or 'murram' on lower slopes; shallow, yellow-brown, gritty soils, overlying, or derived from massive 'murram' of absolute accumulation; grey-black clays of wettish bottom lands; cracking black clays derived separately from trachyte, tuff, phonolite, and basalt or else similar but sandy clays from gneiss; grey to grey-brown sandy loams, over dark calcareous heavy material derived from calcareous tuff; grey-black, heavy but friable soils immediately overlying loose nodular limestone; pallid, cemented, clayey sands as a catenary component between the ferrallitic soils of the higher lands and cracking black clays in metamorphic country. Stony and shallow soils on steep slopes have been grouped together, and also different kinds of a recent alluvia.

105. A total of 15 Soil Families have been mapped and some of these have been further separated into Soil Series according to differences in profile characteristics and analyses. Though mention is made of colour as a useful method of aiding soil recognition, many other basic

soil properties have also been taken into account in classification. The above soil classes have been sorted out in nine Great Soil Groups. During the period under review the soils occurring over a further 250 square miles have been classified and mapped.

106. *Survey of the Ol'Joro Orok Experimental Station, Kenya.* A detailed soil survey of the Ol'Joro Orok Experimental Station of about a thousand acres, extending over both the lower foothills with well-drained, highly coloured soils and also the seasonally wettish soils of the Ol'Bolossat Plain, showed the presence of a wide range of soil conditions. On the basis of morphological features such as the colour, texture, structure and thickness of the natural soil horizons and taking note of the mode of formation, relative topography and drainage, it was found necessary to allow for twelve soil classes. Five of these occur commonly in the Thompson's Falls—Ol'Kalou region, and four have a wide general distribution in the Kenya Highlands. This means that information gained about the agricultural properties of particular kinds of soils can have a wide application. The main representative soil classes occurring on the farm are as follows —

1. A friable, chocolate-coloured, ferrallitic loam.
   A 'murram' horizon occurs in the lower sub-soil where this soil class extends on to the lower slopes.
2. A friable, red to dark red ferrallitic loam over a great depth of a red loam sub-soil with little change except for the presence of some pellet 'murram' near the parent trachyte rock.
3. An orange-brown, slightly heavier soil with some rust-mottling of the sub-soil due to seasonal, slightly impeded drainage.
4. A seasonally wet, orange-brown, sandy clay-loam with pronounced rust-mottling almost up to the surface, and occasionally with a thin covering of a grey-brown silt loam. This overlies a zone of massive 'murram' which in turn overlies an impervious brown clay.
5. A similar wettish soil, but with a pronounced grey-brown uppermost soil with mottling and some incipient 'murram' formation in its lower portion, overlying a chocolate-black impervious clay.

107. The above soils are extensive in this region and are worthy of separate field trials. The remaining soil classes found on the farm are of limited occurrence elsewhere. These comprise hill-top sites with a cap of a greyish-brown, re-sorted material; an orange-red loam, over loose earthy murram; a shallow, greyish-brown, gritty loam over massive 'murram'; a dark brown, gritty, coarse sandy loam with much small pumice fragments (river-terrace material) and a highly fibrous peat of permanent swampland.

108. A Soil Map on a scale of 1:5,000 showing the distribution of the twelve soil classes has been prepared. Based on this map and also external factors, a Land Use Map has also been prepared. This

involves the grouping together of certain soil classes according to their agricultural properties and the breaking up of others to fit in with farm planning. In general, over most of the more developed parts of the farm, the present layout coincides fairly closely with the boundaries of diverse soil classes.

109. *Surveys at Kitale, Kenya.* Mr. Scott carried out a preliminary soil survey of the Grassland Research Station and the nearby Agricultural Experimental Station. For the former, there was a suitable 1:5,000 map with 20-foot form lines and a good cover by aerial photographs; whereas for the latter, there was a farm plan on about the same scale but no air cover. These surveys were the first to be made in detail in peneplained, metamorphic country and showed up the general pattern of soil distribution that could be expected on the Kitale Plain portion of the pre-Miocene peneplain. There has been less differential soil re-sortment on slopes than on similar gneissic peneplains in Tanganyika, where there are well-defined, catenary conditions. This suggests that the land surface near Kitale has for long been protected by later deposits. Except for an occasional steep slope down to a stream, the landscape is now gently undulating, with shallow, filled-in valleys leading from the relatively higher land in the vicinity of the township. The summits of some of the ridges have ancient caps of brownish-grey, somewhat compact, sandy loams over a brownish-orange 'mantle' material, or else a dark brown, crumbly loam, over a brownish-red sandy loam derived from the same kind of parent material. Locally, at the base of the latter there is a well-defined quartz 'stone line', under which massive 'murram' can occur. In the case of gentle slopes and undulating high ground, there is usually a dark brown, compact, sandy loam, overlying a good depth of an orange-red sub-soil derived from gneiss. On the middle to lower slopes, the sub-soil is a yellowish-brown, slightly mottled, sandy loam with occasional pisolitic concretions, indicating a certain amount of lateral seepage from the higher land. This is overlaid by a brownish-grey to dark-grey loamy sand. The bottom lands alongside the streams have a grey, compact, mottled, clayey sand which is alluvial in origin, covered over by a hillside wash of brownish-grey to grey loamy sands with mottling at their base. Within this belt, and also alongside secondary streams on relatively steeper slopes, there are strips of recent sandy alluvium.

110. The soils were separated into seven soil classes, all of which occurred on the Grassland Research Station and two only of these at the smaller Agricultural Experimental Station. The most extensive kind comprises the mainly sedentary soil from gneiss. This has a fair range of minor variations in colour, structure and consistency, such that there

is a need for further sub-division in the case of experimental stations. As the soils were very moist when the survey was done, further mapping had to be postponed until they had dried out. Provisional soil maps have been prepared, but these need checking and amplification under more suitable field conditions.

111. *Survey at Loljoro, Tanganyika.* In October Mr. Scott carried out a reconnaissance survey over about 30,000 acres of recently alienated land in the Loljoro area of the Northern Province of Tanganyika. The dominant soil classes in the ridge country are black and dark brown, cracking, slightly calcareous clays, mainly on the flatter lands; and a reddish-brown loam, overlying a brownish-red, compact loam derived from hard lava, occurring on the steeper slopes and as aprons round the hills. The dominant soil class in the lower lying country is a grey-brown to chocolate-brown, crumbly clay loam, passing into a chocolate-brown, cloddy clay loam derived from tuff. Confined to the banks of the Olomotoni River, there is a widening belt of a grey, fine sandy loam consisting of six inches to three feet of waterlaid volcanic ash, overlying a chocolate-brown clay loam which comprises the adjacent soil class. During drought periods this soil is dusty and difficult to cultivate. Apart from the question of drought, about three-quarters of the area surveyed is suitable for cultivation. The remaining land consists of escarpment, ravine and steep hillsides with stony shallow soils. Twenty sets of profile samples, comprising 82 separate soil samples, were taken and later analysed by the Soil Chemistry Section.

112. The Loljoro region, at an altitude of 4,200 to 4,500 feet, is characterised by a semi-arid climate with an unreliable two-season rainfall totalling about 25 inches. This is reflected both in the nature of the natural vegetation and in the soil conditions. The well-drained, medium-textured soils carry Combretum-Savannah with *Themeda trianda*, whereas the heavier soils with seasonal impeded drainage have Acacia-Grassland. Under warm conditions with a relative low rainfall, the porous soils are only slightly leached as shown by slight acidity (pH values of 6.6 to 6.8) and high base saturation. They have a high content of exchangeable calcium and more especially of magnesium and potassium, throughout the soil profile. The heavier soils contain high amounts of all the exchangeable bases with almost complete base saturation, together with some free calcium carbonate. In common with other areas below Meru, the heavier soils contain much exchangeable sodium. This holds for such soils on the flat tops of ridges as well as for the bottom-lands. Those with most sodium are the dark brown and black, slightly calcareous clays on elevated land and upper gentle slopes, and also the

grey, ashy fine sandy loam deposited on the banks of the Olomotoni River. The values for exchangeable sodium range from 1.5 to 2.5 m.e. per 100 gr. in the surface soil with higher values up to 5 and 8 m.e. per 100 gr. in the lower sub-soil. The exchangeable-sodium percentage in the surface soil does not exceed 5 such that growth can be normal, but the corresponding values in the lower sub-soil range between 10 and 15 with odd values of 20 and 25. These ratios of sodium saturation, together with high soil pH values of 8.8 to 9.0 show marginal conditions for plant nutrition and may offer a clue to any crop failures. Another feature of the heavy calcareous soils is the presence of relatively high, but harmless, amounts (0.4 to 0.8 m.e. per 100 gr.) of exchangeable strontium. Under low rainfall the soils have relatively low amounts of organic matter and total soil nitrogen. The arable soils are chemically fertile. It is a low and unreliable rainfall that limits agricultural development.

113. A map on a scale of 1:25,000 has been prepared showing the approximate distribution of the nine soil classes noted in this region. The computed acreages of the different soils were given in the accompanying Soil Survey Report.

114. *Survey of South Busoga, Uganda.* In the 1953 Annual Report some preliminary notes were given about a soil survey of an area of about 150 square miles in South Busoga, which was done towards the end of that year. This special survey was made for the purpose of assessing the suitability for large-scale cane production of a region which had for long been depopulated by epidemics of sleeping sickness, and which had since reverted to forest and dense thicket. In this inaccessible region, with a very short range of visibility, the survey had to be carried out along a set pattern of surveyed traverse lines cut through the dense vegetation. Together with prepared vehicle tracks, the total length of such traverse lines, accurately marked on a scale of 1 : 10,000, was a little over 200 miles. The kinds of soils present were noted ; their boundaries were indicated where they crossed the traverse lines, but delineation had to be based largely on interpretation from aerial photographs. Some soil boundaries associated with differences in drainage and hence with sharp changes in the vegetation, such as the limits of heavy, wettish, bottom-land soils with a grass vegetation, could readily be interpolated between adjoining traverse lines.

115. Use was also made of noted catenary conditions in mapping certain soil sequences, which were associated with relative slope and showed up under the stereoscope. Similarly, the shallow soils on the hill slopes could readily be marked. However, though twelve different soil classes were recognised, some of these could not be mapped separately

—except where their boundaries crossed the traverse lines—and had to be grouped, thus reducing the mapping units to eight.

116. The approximate acreages of the latter were computed from the soil map and also estimates given of the proportions of component soil classes within the compound units. About 60 per cent of the total acreage comprised upland ferrallitic soils derived from granite, of which about a third only was truly sedentary, with a high proportion of coarse material: the remaining two-thirds comprised grit-free 'mantle' soils. The sloping land with well defined soil sequences, situated between the uplands and the heavy, wettish bottomlands, occupied a quarter of the whole area, and the heavy and wettish bottomlands comprised 15%, of which about one-third was permanent swamp. Based on field conditions and laboratory analysis, observations were made on the likely suitability for cane production of the twelve soil classes occurring in the region surveyed.

117. A comprehinsive report on the soils, and other factors bearing on the project, was accompanied by a soil map on a scale of 1:25,000.

CLASSIFICATION OF EAST AFRICAN SOILS : FIRST TENTATIVE LIST OF GREAT SOIL GROUPS (1—27) ARRANGED UNDER SOIL SUB-ORDERS (A-L)

A. *Soils of hot and arid regions.*

1 Red desert soils.
2 Grey desert soils.

B. *Plains Soils of semi-arid regions.*

Pallid light-textured soils.

3 Cemented, non-calcareous, Plains Soils.
4 Non-calcareous, Plains Soils.
5 Calcareous, Plains Soils.

Dark, heavy soils.

6 Calcareous, heavy brown soils.

C. *Cracking Black Clays.*

7 Calcareous, cracking, grey black to black, sandy clays to clays ; with the separation of
(a) topographically-determined soils and
(b) lithologically-determined soils.

8 Non-calcareous, cracking, grey black to black, sandy clays to clays ; with the separation of
(a) topographically-determined soils and
(b) lithologically-determined soils.

D. *Black Clays, with pallid upper solum.*

9 Black clays with pallid, silt loam upper solum.

E. *Planosols.*

10 'Low-catenary,' planosols.

F. *Ferrallitic Soils with pallid upper solum*, sub-divided into

(a) with no, or only occasional concretions of sesquioxides.
(b) with pronounced pisolitic, fragmentary or massive concretions of sesquioxides.

11 Orange-Brown to Yellow Brown, Ferrallitic Soils with pallid upper solum. Sub-divisions (a) and (b).
(Some may be ferrallitic-podsolic soils, but for the present remain in this general group).

G. *Ferrallitic Soils, not associated with pallid upper solum* sub-divided into

(a) with no, or only occasional concretions of sesquioxides.
(b) with pronounced pisolitic, fragmentary or massive concretions of sesquioxides.

12 Dark Reddish Brown, Ferrallitic Soils ; sub-divisions (a) and (b).
13 Red Ferrallitic soils, sub-divisions (a) and (b).
14 Orange-Brown, Ferrallitic Soils, sub-divisions (a) and (b).
15 Yellow-Brown, Ferrallitic Soils, sub-divisions (a) and (b).

H. *Hydromorphic soils.*

16 Ground-water Ferrallitic soils.
17 Gley soils (Wiesenboden).
18 Acid peat swamp soils.

I. *Calomorphic soils.*

19 Rendzina Soils.

J. *Halomorphic soils.*

20 Solonchak.
21 Solonetz.
22 Soloti soils.

K. *Juvenile Volcanic Soils.*

23 Volcanic soils with pelalfer trend of weathering.
24 Volcanic soils with pedocal trend of weathering.

L. *Soils with no profile development.*

25 Lithosols, sub-divided into ' escarpments,' ' truncated soils,' ' lava plains ' as land types, and raw, ' ash and pumice ' soils.
26 Water-laid deposits : sub-divided into ' above flood plain alluvium,' ' flood plain alluvium ' and tidal flats.
27 Wind-borne deposits.

PLANT IMPROVEMENT AND PROTECTION

CASSAVA BREEDING

L. R. Doughty, D. L. Jennings and D. W. Gourlay

118. This work has been continued on the sub-station at Amani, Tanganyika, and externally on the Sisal Experimental Station, Ngomeni, by continued kind permission of the Tanganyika Sisal Growers' Association. Its purpose is to concentrate the factors controlling resistance to the virus diseases of mosaic and brown streak, and at the same time to maintain the ability to produce a high yield of palatable roots. To this end the most resistant lines, derived from back-crosses to cassava of ceara x cassava derivatives, have been (1) intercrossed, (2) back-crossed with their parents, (3) crossed with hybrids of *Manihot dichotoma* x cassava origin, resistant to disease but poor yielders with woody roots, (4) inbred. In addition, breeding is continuing with *M. catingae* x cassava and *M. melanobasis* x cassava hybrids.

119. It is recorded that a poor set of seed is obtained when the ceara x cassava derivatives are selfed or back-crossed to their cassava parents, whereas there is a good set of seed when these lines are intercrossed. Derivatives of *M. melanobasis* x cassava are good seed producers.

120. *Field trials.* The high incidence of mosaic in a retest of our most resistant strains in 1953, recorded in the last Annual Report (p.26), was a cause for concern. During the second growing season, however, many of these clones showed a complete recovery and did not produce any further symptoms of mosaic; others that did not recover fully, showed much reduced intensity of symptoms. When harvested after twenty months in the field good yields of root were obtained. The clones combining a good yield with a high degree of resistance to mosaic and brown streak were 4723A/26, 46106/27 and 4763/16, which gave yields equivalent to 25, 27, and 35 tons of fresh root per acre respectively. The first is from a second back-cross of a ceara x cassava derivative to cassava and the other two are third back-crosses of similar origin.

121. In the 1953 - 54 resistance trials at the Sisal Experimental Station the incidence of mosaic and brown streak was relatively low. The planting material was taken from plants free from mosaic symptoms, but they had been exposed to infection in an earlier trial. It was recorded in the last report that some 14% of the clones in these trials showed mosaic symptoms in a few plants within one month of planting. The proportion of plants showing symptoms remained very low throughout the trial. The cuttings used in planting these trials were not selected for freedom from the brown-streak virus symptoms. The intensity of the symptoms of this disease at the end of the trial was in

general very much less than that recorded for the parent material at the end of the previous trial. The reason for this is obscure. Fifty-eight of the 496 clones tested in these trials have been selected for resistance to mosaic, brown streak and for yield, and have been planted for a further season's trial.

122. The retrial of 35 selected resistant clones, mentioned in the last report, was harvested in February 1955 after a duration of 15 months. The intensity of mosaic reached in this trial was not very great and it was not possible further to select for a higher level of resistance. The best yielder was 46106/27, which again produced the equivalent of 26 tons of fresh root per acre and remained free from brown streak.

123. Four resistance trials, containing 440 clones from the 1953 series of crosses, which had not been selected for resistance to virus diseases, were planted in the short rains of 1954. Attempts are being made to control and to increase the intensity of mosaic in these trials so that a higher level of selection can be carried out. The experiments described above suggest that under favourable conditions for plant growth the virus may travel down to the base of the plant without causing symptoms; less favourable conditions may arrest the movement so that symptoms of disease are produced. A check in growth, such as is involved when the terminal buds of plants are removed, should have same effect. In two of the resistance trials the effect of removing the terminal buds in early April was investigated. It was found that the treatment resulted in 49 per cent of the plants in the treated replicates showing symptoms of mosaic in their new growth, compared to 29 per cent of the plants in the untreated replicates. 33 per cent of the plants of the resistant control varieties succumbed to the treatment compared to 11 per cent of the untreated. In another trial it was seen that removing the buds early in the season was not as effective as removing them in early April, but a double treatment at both times was the most effective.

124. Up to date we have not succeeded in producing a plant that is immune from mosaic. Over a series of trials with the most resistant types some plants do from time to time produce mosaic symptoms, but in some cases the symptoms are not persistent; recovery is complete in so far as can be determined during the duration of our trials.

125. Storey and Nichols (*Ann. appl. Biol.* **25**, 4, 1938) have shown that the mosaic virus can only be inoculated into a cassava plant through immature leaves, and that symptoms also can only be produced in immature leaves. They have also shown that some 12 - 20 days elapse before the virus enters the stem of an inoculated plant. Experiments have shown that after entry into the plant movement of the virus is fairly

rapid but predominantly downwards. Lateral movement and movement upwards into lateral shoots is relatively slow.

126. To cause serious damage to a plant it would appear that the mosaic virus must remain or develop actively in or near the growing point. Conditions in a fully susceptible plant may be such that the virus has an opportunity of becoming fully systemic within the inoculated shoot. In the more resistant material the host-virus interaction may be slowed down so that symptoms may not be developed on the infected shoot in the normal course of events.

127. This season's experiments show that symptoms can develop in cuttings of symptomless shoots of the more resistant material, particularly from cuttings taken from the base of the inoculated shoot. It is not yet clear whether the complete recovery, i.e. symptomless regrowth during the second growing season, is due to inactivation of the virus in the root or restricted upward movement.

128. Greenhouse experiments indicate that conditions leading to poor development, or a serious check in growth of plants infected with mosaic virus, expedite the appearance of symptoms in material which has proved fairly highly resistant under natural conditions in the field. This helps to explain, in part, some of the conflicting results obtained in field trials.

129. *Quarantine and Distribution.* The attempted quarantine, at Eldoret, of improved cassavas, as an insurance against dissemination of brown streak disease, has not up to date proved very satisfactory owing to the very slow growth at this high altitude. All plants have now been moved to a more sheltered site and the plants look more promising; but on the new site moles are causing considerable damage as soon as plants begin to form root.

130. One small consignment of cuttings has been sent, from Eldoret, to Machakos and a few more will be available soon. No signs of brown streak have been found in any of the surviving plants so that any material sent out from Eldoret can be guaranteed free from this virus.

131. Owing to the danger of introducing brown streak disease into new areas, the only distributions, other than the one mentioned above, have been in the coastal belt of Tanganyika and Kenya. In these areas very few of the latest issues ('47 series) have shown any promise, but several of the previous year's hybrids ('46 series) are being retained for further test. In the Tanga district some clones of both series are promising and in this area a marked tendency to 'recover' from mosaic is noted in the resistant clones as compared with local types.

132. The present position is that, if we can struggle through two season's quarantine at Eldoret to eliminate any brown streak carriers and then propagate material in a more suitable place, e.g. Kakamega, a number of resistant high-yielding clones will be availabe for distribution and test of adaptability in the different cassava-growing areas.

MAIZE BREEDING

L. R. Doughty and T. Graham

133. The investigations of the practicability of the Brieger method for improving maize, for use in native areas, have been continued and several lines from Nyanza Province maize and from the variety *Katumbili* (from Mwanza) have been taken to the third inbred generation and are under observation this season for an assessment of their combining ability. More attention was paid last season to sibbing, as this method of inbreeding appears to attain the same ends as selfing without the considerable loss of vigour noted in seedlings obtained by the latter method.

134. Reporting progress at this stage of the work is difficult. Until the testing of recombinations begins one cannot determine with any exactitude the value of the material being handled. A proportion of the material handled in each generation is discarded for obvious agronomic defects, e.g. susceptibility to disease, weak stems and undesirable cob characters. Resistance to inbreeding is also taken into account and the most vigorous inbred lines retained, but this factor is not necessarily connected with yielding capacity of any recombinations to be made later.

135. During the 1954 season we only had a limited number of selections in their second cycle of inbreeding and a larger number in the first cycle, a total of some 1,400 breeding plots, divided between Nyanza maize, *Katumbili* from the Lake Province of Tanganyika and yellow maize.

136. In the 1955 season we have planted about 1,700 breeding plots of white maize and have not yet been able to cope with the yellow. In addition to these breeding plots we have a continuation of variety trials.

137. *Field trials.* Field trials carried out during 1954 at the Bukura Training Centre in North Nyanza included a comparison of original selections and these same selections grown from the seed obtained from the previous year's trial, i.e. on open pollination. There is apparently little difference in the yields obtained; but the seed produced in 1953

was smaller than that of the original selections, and seeding rate through the machine was therefore heavier than that of the original selections and the final populations were different for the two types, making interpretation of the results difficult.

138. Two experiments were planted in 1954 to determine the effects of different populations and different fertiliser treatments on yield of maize. One of these, at Bukura, was a failure; the plant populations obtained were too variable for the purpose of the experiment. The experiment at Eldoret was concluded satisfactorily.

139. The three populations were 7,260, 10,890 and 14,520 plants per acre. The fertiliser treatments were 0,56 and 112 lbs./ac. sulphate of ammonia and 0,80 and 160 lbs./ac. double superphosphate. Each fertiliser and spacing treatment was planted with five varieties of maize; one of these varieties gave very poor germination and this variety had to be ignored. The experiment was planted and phosphates applied on 29/3/54. The sulphate of ammonia was applied forty days later, a week after thinning out. The experiment was harvested on 17th November, 1954.

140. The salient features of this experiment are:—

(1) Yield per acre of grain increases with an increase in plant population. The final stands in this experiment were 95%, 94% and 93% of the intended population and the difference in yield between the lowest, 6,900 plants p.a., and the highest 13,500 plants p.a., was $4\frac{1}{2}$ bags (of 200 lbs.) of grain per acre. The mean yield was 15.38 bags/ac. (2) There was a significant response to phosphate at 80 lbs./ac., the yields being 13.5 bags with no phosphate, 16.1 bags with 80 lbs., and 16.5 bags with 160 lbs. (3) Sulphate of ammonia in this experiment caused a significant ($p.=.05$) decrease in yield:— no nitrogen, 16.6 bags/ac.; 56 lbs./ac., 15.0 bags/ac.; and 112 lbs/ac., 14.5 bags/ac. (4) The varieties all behaved in a similar manner in response to treatments and all yielded at about the same rate. (5) There was a higher proportion of passengers i.e. non-silking plants, at the high population density than at the low, which is reflected in a lower number of cobs per plant at harvest. The effect of phosphate is apparently to ensure a higher proportion of productive plants irrespective of the population.

141. This year, 1955, we are responsible for two of the eleven co-operative maize variety trials. These are being conducted at various centres in the three East African territories in order to assess the potential values, in East Africa, of part of the range of material available at various maize-breeding centres. The trials contain the same thirteen varieties at all places. One of our trials is at Eldoret and the other at Bukura. We are also giving assistance, from Amani, with another of these trials

at the Sisal Experimental Station, Ngomeni. With the exception of one variety, full stands have been obtained at Eldoret and Bukura.

142. *Streak disease.* Some 1,800 maize seedlings, derived mainly from Peruvian stocks and Peruvian x Muratha crosses, were tested for evidence of resistance to streak disease during the year. Resistant plants were intercrossed in pairs but owing to the ravages of stem borer only six small cobs were harvested. During this season's tests only one in five (approx.) of the inbred Peruvian maize seedlings showed resistance to streak disease, whereas in the previous season the proportion was approximately two out of three seedlings resistant to infection. Amongst the derivatives of the Peruvian x Muratha crosses the proportions of resistant seedlings were very similar to those for the Peruvian inbreds.

143. In 1954 we crossed a number of *Katumbili* derivatives with Peruvian. This material will be sibbed before testing for resistance.

144. The shaded propagation site effectively prolonged the growing season of the seedlings but also provided an off-season feeding ground for stalk borer.

GROUNDNUT BREEDING

D. L. Jennings

145. In the previous report it was stated that a proportion of the pollinations carried out between the groundnut, *Arachis hypogaea*, and the diploid species *A. diogoi*, *A. prostrata* and *A. glabrata* had produced seedless fruit and that no sound seed had been produced from these crosses. Some observations have been made on the embryology of the groundnut in an attempt to elucidate this. According to Reed, who studied the embryology of the groundnut in 1924, fertilization of the flower stimulates the elongation and growth of a region between the receptacle and the ovary so that a gynophore is formed, which then takes the fertilised embryo below ground. The ovary remains dormant and does not begin its development until the gynophore has penetrated the ground for 2-5 cms. In the Amani greenhouses, and during the warm months of the year, gynophores appear between seven and ten days after flowering and usually penetrate the ground within three or four days, provided that they are not situated at too high a level on the plants. No difference between the size of the ovule could be detected from the pre-flowering stage to the stage when it penetrated the ground, thus confirming Reed's observation. Development is then rapid and the fruit reaches its full size approximately 28 days after the gynophore penetrated the soil.

146. A large number of interspecific crosses were attempted and in from 10 to 20% of the cases, depending on the time of crossing and the nature of the cross, a gynophore was produced. Some of these failed to reach the ground, but a total of 36 pods were harvested approximately two months after the gynophores first appeared. The embryos contained in the pods were measured and were found to approximate in size to those measured from normal uncrossed flowers seven days after the gynophore had reached the ground. A few interspecific embryos were measured at this stage and were found to be the normal size expected for seven-days development.

147. Although the pollen tubes of the diploid species have not been observed to fuse with the ovule of the groundnut, it is probable that the embryos obtained were true embryos resulting from fertilization. The results suggest that growth of the embryo ceased after seven days. This could have been due to an incompatibility between the endosperm and embryo; artificial cultivation of the embryo may solve the problem.

148. The colchincine-treated plants of *Arachis prostrata*, mentioned in the previous report as being selected on morphological differences, have been cytologically examined and found to be tetraploid. However, crosses between them and the tetraploid groundnut have not been any more successful than crosses using the diploid *A. prostrata*.

149. Dr. A. C. Evans' important results obtained by selection in the variety *Mwitunde* at Nachingwea, Tanganyika, are reported by him in the Tanganyika Agricultural Corporation section of this Report.

PHYSIOLOGY OF THE PYRETHRUM PLANT

J. Glover

150. A final report on the pyrethrum "bud-disease" investigation was made to the Pyrethrum Board of Kenya early in 1954. Studies of the physiology of the plant enabled the elucidation of various aspects of the disease problem.

151. Frequent spraying with Bordeaux mixture effectively controlled the disease to a low level, but occasionally spraying was ineffective. Frequent spraying was necessary because flower-buds were being almost continuously differentiated throughout the growing season and as fast as they were developed they needed protection. The differentiation of the flower-buds is due to chilling at night and on dull days. The temperatures which produce this effect are in the region of the dew-point. Thus they simultaneously stimulate flower production and produce damp conditions favourable for the spread of the disease on already well-

developed buds. Fortunately for the grower bright dry days often succeed damp cold nights and the conditions for rapid spread of the disease do not develop as fast as those which favour bud-production. Thus the disease in normal years does not rise to excessively damaging heights. However if cold and damp persist, as at Molo and elsewhere in 1946, the disease spreads rapidly and causes severe loss. Frequent spraying could ameliorate this but the cost of such spraying may be prohibitive relative to the return.

THE AMERICAN RUST DISEASE OF MAIZE CAUSED BY PUCCINIA POLYSORA UNDERW.

H. H. Storey and A. K. Ryland

152. The background to this research was set out in the E.A.A.F.R.O. Report for 1953. Briefly its purpose was to seek maize plants resistant to the fungus, to breed from these with a view to understanding the genetics of resistance and to producing basic material for issue to maize-breeding stations in the East African territories. During 1954-55 it was continued to the full capacity of the available facilities.

153. The work was carried out in the glasshouses at Muguga. A standardised technique for inoculation of two leaves of a three-leaf seedling has been applied; and selected seedlings have been transplanted to 4-gallon containers and grown to maturity. Thus testing and controlled breeding have been continued independently of season. During the period 1954-55, some 1,500 tests (each of 5-7 test plants together with an equal number of known susceptible controls) were carried out, and some 600 plants were grown on, hand-pollinated and harvested.

154. Selection was based on the reaction of the seedling leaves to inoculation. A fully susceptible seedling gave large spreading uredosori, open at 12-14 days; while in the resistant plant these were replaced by lesions, at first chlorotic but later becoming necrotic, in which either no sori developed or only small sori. Full immunity, as denoted by the absence of any reaction to inoculation, has not been found.

155. As recorded in our 1953 Report, we have found no juvenile resistance in any African maize that we have tested, although workers in Nyasaland and elsewhere have reported apparent grades of susceptibility in the field. These we have failed to recognise in seedling tests. Through the co-operation of correspondents, we have imported 203 maize types from Central America, originating in Mexico, Colombia, Martinique,

Cuba, Haite, St. Croix, Trinidad, Dominica, Jamaica, Puerto Rico, Costa Rica, Nicaragua, Guatemala; and among these the hypersensitive reaction has been detected in 54. No variety or line, as imported, was pure for the hypersensitive factor. By selection and selfing, however, we have now raised 49 inbred lines that are pure for hypersensitivity and, from crosses between certain of these, 30 pure lines. By crossing exotic hypersensitive plants with susceptible locals and twice selfing selected progeny, we have produced 34 lines that are fully hypersensitive.

156. Results obtained in the testing of families obtained in our breeding caused us to conclude that hypersensitivity was controlled by a single dominant major gene. This conclusion was briefly reported in a letter to Nature (*Nature, London*, **73,** 778, 1954). No evidence obtained since has conflicted with this conclusion, except that it now seems possible that there may be two independent major genes concerned, which in the course of our studies were obtained from maizes from different sources.

157. Through the co-operation of a number of officers in Departments, in the Tanganyika Agricultural Corporation and at the E.A.A.F.R.O. outstation at Amani, many of the Muguga-bred lines, whose juvenile reaction to *P. polysora* was known, have been tested in the field. In general it can now be said that the juvenile reaction affords a correct indication of the behaviour of the plant in the field; and that plants exhibiting the hypersensitive reaction as seedlings will continue to do so to maturity.

158. An extensive maize-breeding programme is in progress at several Departmental stations, aiming at the transfer of the gene or genes for hypersensitivity to local maize varieties. Reports on progess may be expected from the officers who have undertaken the work. It need only be reported here that the closest co-operation has been maintained between E.A.A.F.R.O. and Departmental workers. The Specialist Committee on Agricultural Botany, to which progress reports are submitted, has played a large part in ensuring this co-ordination.

159. It is appropriate, however, here to refer to the advance made by Mr. Hemingway, of the Tanganyika Agricultural Corporation, with which E.A.A.F.R.O. has special scientific ties. He has been engaged on transferring the gene, isolated originally at Muguga from the variety "Colombia 2" (received from Estacion Agricola Experimental, Medellin), to the widely-grown maize race *Katumbili*. He has made rapid progress; and bulk issues of a resistant *Katumbili* may be confidently expected soon. His report on this work appears in the Tanganyika Agricultural Corporation section.

160. In the Muguga glasshouse it has been found that the transplanted maize seedlings, if the half bushel of soil available to their roots receives regular accretions of liquid nutrients, will grow strongly and yield well. The artificial conditions could not be expected to afford much indication of what would be each line's growth and general behaviour in the field. Nevertheless since many grew in the glasshouse as strongly as, or more strongly than selected local maizes, it appeared worth while to issue some for direct trial at experiment stations. A number of selected resistant lines have been so issued in 1955; but reports on their behaviour are not yet available. If any prove to be as productive as the (generally unimproved) local varieties, it will be possible, probably as a temporary measure, to begin issues of resistant seed in advance of the issues from breeding stations.

161. The work so far described and the tentative conclusions drawn rest on the assumption that only a single physiologic race of *P. polysora* has become established in East Africa. In the Muguga experiments we used from the start material of the fungus collected at three sites—from Zanzibar, from the Amani district of Tanganyika and from Uganda. All our maize lines were tested against at least two of these "locality strains"; but since no significant differences appeared in these replications, we concluded that the samples collected from these widely separated localities all belonged to a single race.

162. In January 1955, however, certain maize lines under test in the Muguga houses behaved anomalously; lines that were expected to show the hypersensitive reaction developed the normal necrotic lesions, but scattered among these were a few large sori typical of a susceptible reaction. From these sori a race of the fungus was isolated that was physiologically different from that with which we had previously worked. Maize derived from the "Colombia 2" variety and uniformly resistant to the old race of rust was fully susceptible to the new race; but the majority of our derived lines from other sources reacted in a similar manner to both races of rust. This finding was reported in a letter to *Nature*, not yet published.

163. There appears to be no doubt that a new physiologic race of *P. polysora* has appeared in the Muguga glasshouses. So far no reports have reached us of a breakdown in the resistance of the "Colombia 2" derivatives at any field testing station in East Africa. But the fact that the new race has appeared in our glasshouses, whatever may have been its origin, emphasizes the danger that this new race—or indeed others having a virulence different from either that we have studied—may at any time become established in the maize fields of the affected areas.

If so, control of the rust in the field, through the use of resistant types of maize may require an indefinite continuation of the breeding studies that we and colleagues elsewhere in East Africa have undertaken in the past two years.

VIRUS DISEASES OF SWEET POTATO

F. M. L. Sheffield

164. The search for insect vectors, which has occupied most of the period under review, has led to the recognition of those responsible for transmitting what now appear to be two groups of viruses. A next stage in this research is to attempt, by the use of these vectors, to discover alternate hosts of the Sweet potato viruses. Work is also in progress to decide whether the viruses can be inactivated by heat treatment of tubers; but so far no success has been recorded.

165. There appeared to be little spread of the viruses in the field at Muguga, but, in 1952, it was very considerable in a field at the Jacaranda Coffee Research Station. Collections of sucking insects were therefore made at 12 consecutive monthly intervals from Sweet potatoes grown on the Jacaranda estate. I must express my gratitude to the Officer-in-Charge and to the staff of Jacaranda for the facilities and assistance given me. The insects were brought to Muguga where their ability to transmit virus disease was tested.

166. It was realised only after these experiments had been started that climatic conditions could have a considerable effect on symptom expression. This became evident when a large number of infected tubers were needed for some proposed experiments; and to multiply available stocks, plants infected by grafting and showing severe symptoms were set out in the open at Muguga at the beginning of the long rains and just before the cold season of 1954. Some of these plants became so severely affected that they died; from others, all symptoms except a slight stunting disappeared, whilst the remainder were indistinguishable from healthy plants. By grafting of scions from the last group to healthy plants in the glasshouse, it was found that in some the virus was not fully systemic, whilst from others it had completely disappeared. In the hot season, plants which failed to show symptoms in the glasshouse, did so within one month of being placed outside. These conditions are not yet fully understood and they complicate the interpretation of results of transmission experiments.

167. It was reported in 1951 that I was able to find few plants showing primary infections at high altitudes and none at low. This

observation was then interpreted as suggesting that the vector is rare at high levels and absent from low. It now seems more probable that the symptoms are masked or the virus is inactivated by climatic condition occuring at certain seasons in high areas and they may also be masked in the warm humid conditions prevailing at low altitudes.

168. In my 1953 Report I recorded that viruses brought from the field fell into six groups, the apparent differences being in degree of severity only. It then seemed likely that they were strains of a single virus, so, in the first insect transmission experiments, only the more severe forms were used. Later, experiments were performed with the mild viruses and for these a different vector was found.

169. *Insect Transmission of the Severe Viruses.* The insects collected and tested are listed below, together with brief descriptions of the experiments performed. A preliminary trial was made of all but one species by the rather crude method of releasing insects into a glasshouse containing infected and healthy plants. Usually only insects of one family were deliberately released into one house; but, as no control measures could be taken, it was not always possible to exclude invaders such as aphids and red spider. After several weeks, the house was fumigated and, after a further interval, the plants were cut back. If after several weeks, they showed no virus symptoms, they were planted outside. Some of the insect species were simultaneously bred for more exact experiments by methods that ensured that accidental invaders were excluded.

170. With the exception of Whitefly, all the insects tested failed to transmit the severe viruses.

APHIDS. *Aulocorthum vincii. Macrosiphum euphorbiae*, *Myzus persicae*, identified by Dr. V. F. Eastop, all of which breed freely on Sweet potato, were released into a glasshouse as described above.

A further similar experiment was done with aphids collected from plants other than Sweet potato by Dr. V. F. Eastop and identified by him. None bred on Sweet potato. They were: *Aphis craccivora* (Koch), *A. solanella* (Theobald), *Chaetosiphon fragaefolii* (Cockerell), *Dactynotus compositae* (Theobald), *Hypermyzus lactucae* (L), *Myzus ornatus* (Laing), *Rhopalosiphum maidis* (Fitch). *M. euphorbiae* (Thomas) was again included in this experiment.

In addition the first three species mentioned were bred on caged infected plants and were then transferred to healthy plants under lamp glasses. Others were bred on healthy plants starved overnight and fed for a very short time on diseased plants before being transferred to healthy plants under lamp glasses. 140 experiments were done using 10-20 insects for each.

LEAFHOPPERS. Six unidentified species were found on Sweet potato but only one would breed on it. As well as being tested in the open glasshouse these were fed on diseased shoots in muslin bags and were later transferred to healthy shoots in similar bags. 30 transmissions were tried using 10-20 insects.

FROGHOPPER. One species was found feeding on Sweet potato but would not breed on it. The few insects collected were released into a glasshouse.

THRIPS. *Dendrothripoides ipomoea* (Bgn.) (identified by Dr. Hartwig) and another unidentified species both bred on Sweet potato. They were tested as vectors in the open glasshouse only.

MEALYBUGS. *Planococcus Kenyae* (identified by Dr. A. R. Melville) bred on Sweet potato. As well as being tested free in a glasshouse this species was also bred on caged infected plants. Insects were then transferred by brush to 92 healthy plants under lamp glasses.

Another species thought (by Mr. G. de Lotto) to be *Trionymus* sp. was invariably confined to underground parts of the plant and was therefore unsuitable for testing by the cruder method. It was bred on sprouted Irish potatoes in the dark. Small Sweet potato cuttings were rooted in sand through 1½ in. long glass tubes of ½ in. diameter. When the cutting was rooted the bottom of the tube was plugged with cotton wool and the cutting was planted in soil. Insects were put in the tube the top was plugged and the tube buried in sand. Insects were first fed on infected and then on 60 healthy cuttings.

MITES. Red spider, probably two species, found breeding on Sweet potato, *Aceria* sp. (identified by Dr. G. O. Evans), which causes erinose of Sweet potato, and another unidentified eriophyid mite which causes bronzing of the foliage were tested free in the glasshouse only.

WHITEFLY. Whitefly (not yet identified) found breeding on Sweet potato in three different localities were tested first in the open glasshouse when 15 out of 60 healthy plants became infected. Detailed and carefully controlled experiments are now in progress to determine the host-virus-insect relationships. Symptoms take a minimum of 10 weeks to become apparent and in the hot season may be masked in the glasshouse and show only when transferred to the field. More than half of the first hundred controlled experimental transmissions were successful and there can be little doubt that a severe virus of sweet potato is carried by whitefly.

171. *Insect Transmission of Mild Viruses.* It was reported by Webb and Larson (*Phytopath.*, **44**, 290) that the feathery mottle virus of Sweet potato is transmitted by *Myzus persicae*. It seemed possible that this virus is the same as a mild form found at Kawanda, near Lyamungu and at Jacaranda. The first two of these have now been shown to be transmitted by *M. persicae* and to be non-persistent in their insect vector.

VIRUS DISEASES OF STRAWBERRIES

A. K. Ryland

172. At the request of the Kenya Department of Agriculture experiments were undertaken to decide whether an abnormal condition in local strawberry plants was due to virus infection. Symptoms in the field strongly suggested the "Crinkle" complex; but experimental confirmation was desired of the observational diagnosis.

173. Affected plants of the variety "Cambridge Regent" (No. 679) were transplanted to the Muguga glasshouses, together with apparently

healthy plants of a second "Cambridge" variety, "Early Pine" (No. 448) as test plants. Difficulties arose through the failure of the former variety to produce runners. (This was later overcome by artificial lighting to provide an 18-hour "day".) This failure precluded the use of the standard runner-inarching technique for virus transmission. However by the use of Nattrass's leaf-graft method, in which the petiole of a single leaf was inserted into a runner and humidity maintained by enclosing this runner in a polythene sleeve, good survival of the leaf was obtained and the suspected virus was transmitted.

174. In early experiments transmission was not recorded and the Early Pine plants remained apparently healthy. When however leaves from these experimental plants were grafted to a third, unnamed, strawberry variety, symptoms resembling those of the original Regent plants resulted. Meanwhile further plants of Cambridge Early Pine had been obtained; these were showing crinkle symptoms in the field. Leaf grafts from them also resulted in crinkle symptoms in the unnamed variety.

175. This work was undertaken with the limited objective stated in the first paragraph, and no attempt was made to analyse into component viruses what on European experience was likely to be a complex. But it appeared from our results that the original Regent plants were carrying a virus, or viruses, that remained masked in Early Pine. On the other hand, Early Pine was not a symptomless carrier of all the viruses occurring, for crinkled plants could be found in the field and from these a virus could be transmitted to the unnamed variety.

176. These results were not unexpected, since strawberry stocks have been imported in the past as vegetative material and must almost inevitably have carried viruses prevalent in the country of their origin.

INSECTS PESTS OF FOREST TREES AND TIMBER

J. C. M. Gardner

177. Mrs. Brown took up her duties in a subject new to her in March 1955. The remainder of the staff consists of three young Africans, two of them recently appointed. Since the present forest entomologist started work in East Africa in 1950 (at first with the Kenya Forest Department), when very little information had been recorded, the section has made satisfactory progress; in fact the work now in hand has become far too much for the small staff to tackle. Touring has been difficult because of laboratory work requiring constant supervision; in addition,

field work has been impeded by emergency conditions coupled with the fact that African assistants were not allowed to leave the station.

178. *Co-operation with the three territories.* The Kenya Forest Entomologist (Mr. S. J. Curry) and an Insect Forester (Mr. J. O. Evans) have worked in close collaboration with the Forest Entomologist E.A.A.F.R.O. The first has been investigating damage to newly felled logs by Ambrosia Beetles, with special reference to their distribution, biology and control; there is a very considerable, although not yet accurately estimated, wastage of timber from this cause. One aim of this investigation is to test the efficiency of spraying logs with benzene hexachloride (found promising elsewhere) under Kenya conditions and to produce a reasonably economic prescription. Mr Evans continues to specialize in field work on the *Oemida* problem, referred to later.

179. Of the two African forest rangers trained for insect survey work in Uganda only one has been so occupied on full time. Two African insect rangers, trained at E.A.A.F.R.O. for work in Tanganyika, have been working for the last three months of the period under review.

Survey of East African Forest Insects

180. Considerable advances have been made in this subject with special reference to species of insects, their host trees, localities and probable economic importance. A great deal of this information derives from the policy of employing African observers. We now know at least something of the habits of about 650 species of forest insects, although all have not yet been identified. It is proposed to maintain this survey continuously, with, it is hoped, the continued help of forest officers, and gradually to make it more quantitative than it has been. We now have some idea of the definitely dangerous species and of the species that might prove to be dangerous because of intensified forest operations, in particular the establishment of large areas of exotic trees as well as of indigenous trees.

Intelligence Services

181. *Records.* The ledger-file records and card indexes are practically up-to-date.

182. *Identification of Insects.* Our reference collection of authoritatively identified insects is mounting rapidly, thanks chiefly to the Commonwealth Institute of Entomology, which receives from us a continuous stream of material for examination. One embarrassment is that

such a large proportion (about a third) of our bred insects are new species or at least not represented in the British Museum collection. These must wait until specialists (of whom there is a serious shortage) can be found to deal with them. Even with a good reference collection the identification by comparison of the large numbers of insects acquired every month is time-consuming and difficult, since descriptive literature is widely scattered in journals that are not available at this station.

183. Particular attention has been given to the building of a collection of identified larvae for the purpose of classification and rapid diagnosis. Our collection of Cerambycid larvae with relevant biological information has, it is understood, proved of considerable value to Mr. E. A. J. Duffy of the Commonwealth Institute of Entomology, who is producing a monograph on the African Cerambycidae.

Special Problems

184. *Oemida gahani* Distant. This, a species of Cerambycidae, is the most important forest-insect problem in Kenya, with special reference to the extensive cypress plantations; it is present in certain plantations in Tanganyika and is known, but not yet as a pest, from Uganda, where survey work is in progress. Essentially a dead-wood borer with a large number of host species, it can ruin the heartwood (regarded here as "dead wood") of cypress without giving visible signs of its presence on the outside of the standing tree. The female oviposits on external scars, including pruning scars, whence the larvae reach the heart. Field experiments, mostly long-term, have been set up in the Londiani forest division by Mr. Evans, who is specialising on this problem. Observations in the E.A.A.F.R.O. insectary over five years indicate that the adults emerge throughout the year, but with peaks coinciding with the two periods of most rain. Mr. Pudden (Silviculturist, Kenya) has carried out interesting experiments bearing on the reduction in size and rapid occlusion of pruning scars. No record exists so far of attack on healthy standing *Pinus* spp. and there is a possibility that this genus may be resistant; this suspicion must, however, be treated with reserve, for pines have been planted in the past on a small scale and only a relatively small amount has reached the saw-mill. Taking this as a reasonable risk, the planting of pines in Kenya is being stepped up.

185. *Damage to seasoned wood.* Two years ago very considerable losses to timber were due to attack by Bostrichidae and Lyctidae, chiefly because the use of sapwood was on the increase; however, plants for impregnation with protecting chemicals under pressure are in action

or planned and damage from this cause should no longer be serious. Incidentally, attack to *Podocarpus* structural timber by *Oemida gahani*, a species referred to in a previous paragraph, should also be covered by impregnation, with the proviso that this borer is not limited to sapwood (with high starch content) as are the powder-post beetles.

186 *Defoliation.* No really serious defoliation by Lepidoptera has yet appeared, although some local epidemics were at first alarming, but died out with no preventive measures having been taken. A plantation of *Juniperus procera* in the Thomsons Falls forest division (Kenya) was nearly completely defoliated by the Saturniid *Nudaurelia rhodina* Roths. in October, 1954, but the larval population was enormously reduced by a disease (probably bacterial): from a sample of two hundred full-grown larvae only three adults were reared. The Lasiocampid, *Gonometa podocarpi* Auriv., occurs sporadically in Uganda and Kenya on species of *Cupressus* but does not seem to be as great a risk as at first suspected, probably because of efficient parasitism especially by the Tachinid *Sturmia gilvoides* Curran; in this case the average production is 35 parasites per affected larva. There are numerous other cases being watched, but so far there has been no succession of generations causing serious damage and the trees have recovered. However, with the great changes being made in the constitution of the forest by making pure plantations, especially of exotics, it must not be assumed that seeming immunity will continue. No introduced moth pest has yet been recorded, although *Nudaurelia cytherea* var. *capensis* Stoll., a serious defoliator of pines in South Africa, was once reported to be in Kenya (*Rept. Forest Dept. Kenya*, 1945—47, 1949); this record appears to be erroneous.

187. *Gonipterus scutellatus* Gyll. The Eucalyptus Weevil (introduced from Australia via South Africa) can cause serious damage to susceptible species in Kenya, especially in areas where, because of local climatic conditions, the adult or pupa hibernates; the reason for this is that the egg-parasite *Anaphoidea nitens* Gir. (deliberately introduced years ago) obviously cannot continuously find the necessary egg-masses. The Forest Department, Kenya, was advised to encourage the planting of non-susceptible species, although this rules out one or two of the more wood-productive species. It is of interest that in Tanganyika this weevil has not yet been recorded, and that *Eucalyptus maideni* and *E. camaldulensis*, two of the most susceptible, are being grown with great success.

188. *Phytolyma lata.* The "mvule gall Psyllid" is a wide-spread pest of *Chlorophora excelsa* in East Africa and its control is regarded as a priority subject. The use of insecticidal sprays is limited owing to the fact that the greater part of the life-cycle is spent completely en-

closed in the gall. The Forest Ecologist, Uganda, states that pilot experiments with systemics show that these are effective for about six weeks; in any case the cost and toxicity of those systemics now available would rule them out.

189. *Nursery pests.* Cockchafer larvae of various species (*Anomala keniae* Ohaus being apparently the most prevalent in Kenya) have been efficiently controlled by admixture of benzene hexachloride with the top four inches of soil before sowing seed. The Noctuid *Euxoa segetis* Schiff. is the most prevalent cutworm and succumbs to the same treatment. In May and June, 1955, serious damage to seedlings by wingless weevils of seven species of Otiorhynchinae was reported from the Coast of Kenya and from the Highlands.

190. *Other Subjects.* There are numerous subjects (and the protection of plantations from termites is one of them) each of them requiring the full-time investigation that may be possible when an adequate staff of entomologists is available.

APHID TAXONOMY AND BIOLOGY

V. F. Eastop

191. The first three months of 1954 were spent in Nachingwea, Tanganyika. April 1954 to early March 1955 were spent mostly at Muguga, with short collecting trips to Molo and Mombasa, Kenya and to Marangu and Amani, Tanganyika. I returned to the United Kingdom in March 1955, and have been working in the British Museum since early April.

192. Only about 20 species of aphids were found in the five mon hs spent in the Southern Province of Tanganyika. Although 1,361 aphids were taken in traps and many colonies were collected, such well kno wn pests as *Myzus persicae*, *Aulacorthum vincae* and *Macrosiphum euphorbiae* were not found. The species seen were, *Aphis craccivora* Koch; *A. gossypii* Glover; *A. nerii* B.d. Fonsc.; *Brachyunguis pseudocardui* (Theob.) sub-sp.n.; *Dactynotus compositae* (Theob.) sub-sp.n.; *Lipaphis pseudobrassicae* (Davis); *Longiunguis sacchari* (Zehntner); *Macrosiphum* (*Sitobion*) sp.or spp.; *Paoliella* sp. on *Commiphora pilosa; Pentalonia nigronervosa* Coquerel; *Pterasthenia shiraensis* Stroyan; a single specimen probably representing a new genus near *Pterasthenia* Stroyan; *Rhopalosiphum maidis* (Fitch); *Rh. splendens* (Theobald); *Schoutedenia bougainvilleae* (Theobald) (feeding on Euphorbiaceae, not normally on *Bougainvillea*); *Tetraneura hirsuta* (Baker); *Unipterus papillata* Hall and five un-

described species or sub-spp. of *Unipterus*, and *Yezabura rhodesiensis* (Hall).

193. Very few aphids were flying at Nachingwea during November and December, 1953. The first to fly in large numbers was *Schoutedenia bougainvilleae*, 54 of the 56 aphids trapped in the first half of January being this species, as were 44 of the 74 trapped in the second half of the month. In February large numbers of *Aphis gossypii* (39), *Longiunguis sacchari* (726), *Rhopalosiphum maidis* (42), *Schoutedenia bougainvilleae* (94), and *Unipterus* spp. (97) occurred in the traps. In early 1954 the *Aphis craccivora* population was kept low by several species of syrphid larvae, of which *Ischidion aegyptiacum* Wild. and *Paragus borbonicus* Macq. were the commonest. By March the syrphid pupae were themselves heavily parasitized by Hymenoptera, ? *Ooencyrtus* sp. and *Cheiloneurus cynnonotus* Watst. (Syrphids and parasites determined by the Commonwealth Institute of Entomology).

194. About 80 species of aphids are now known to occur in East Africa. The following species have been found, or been described since a list of East African aphids (*E. A. Agric. J.* **18,** 133—5) appeared: *Acyrthosiphon bidentis* Eastop; *Aloephagus myersi* Essig; *Brachycaudus amygdalinus* (Schout.); *Brachyunguis* spp.; *Capitophorus eleagni* (Guercio); *C. hippophaes* (Walker) sub-sp.n.; *Ceratovacuna* ?*lanigera* (Zehtner); *Chaetosiphon fragaefolii* (Cockerell); *Ch. tetrahodus* (Walker); *Coloradoa rufomaculata* (Wilson); *Eucarazzia elegans* (Ferrari); *Hyalopterus pruni* (Geoffroy); *Metopolophium* ?*dirhodum* (Walker); *Micromyzus* spp.; *Paoliella* sp. or spp.; *Pseudaphis sijui* (Eastop); *Pterasthenia shiraensis* Stroyan and the related species mentioned above; *Rhopalosiphoninus staphyleae* (Koch); *Rhopalosiphum nymphaeae* (L); *Rh. padi* (L); *Rh. splendens* (Theobald); *Saltusaphis scirpi* Theobald; *Sappaphis* (*Dysaphis*), *foeniculus* (Theobald); *S.* (*D.*) *tulipae* (B.d. Fonsc.); *Trifidaphis phaseoli* (Pass.); *Unipterus commiphorae* Doncaster; and 4 undescribed species and 2 sub-species of *Unipterus.*

195. For the past two years the seasonal pattern of aphid population growth and aphid flight have been very similar, with large population build-ups at the end of the rains, May—June and November—December, and large aphid flights in June—July and in January.

196. Work on the British Museum aphid collection and recent literature has shown the following nomenclatural changes affecting African Aphids. *Acaudus calami* Theobald and *Aphis acori* Theobald= *Schizaphis cyperi* (van der Goot). *Aphis africana* Theobald=*Rhopalosiphum maidis* (Fitch), not *Longiunguis donacis* as was previously suggested. No true material of *Aphis fabae* has yet been seen from East Africa,

all the specimens seen being the very similar *Aphis solanella* Theobald. *Aphis pheidoleae* Theobald=*Longiunguis sacchari* (Zehntner). All the African material seen determined as *Aphis pomi* or *Aphis pomonella* Theobald is *Aphis gossypii* Glover, as is probably also *Aphis pruniella* Theobald. The aphid usually known as *Cerataphis lataniae* Boisd. in East Africa is not that species but is *variabilis* H.R.L. This species has now been seen from the Belgian Congo, Gold Coast, Kenya, Sierra Leone, Tanganyika, Zanzibar, the Seychelles and many parts of Asia. No true *lataniae* has been seen from Africa. A sample of *C. orchidearum* Westwood was intercepted by the Kenya Department of Agriculture on Orchids imported from New Zealand in 1938. The *Geoica* sp. recorded from Cotton roots in Uganda was *Trifidaphis phaseoli* (Pass.). *Macrosiphum* (*Sitobion*) *sijui* Eastop has been made the type of *Pseudaphis* Hille Ris Lambers 1954. The aphid known as *Neophyllaphis podocarpi* Takahashi in Africa is not that species but is as yet undescribed. It has been seen from Kenya, Tanganyika, and Transvaal. *Rhopalosiphum carduellinum* Theobald=*Hyperomyzus lactucae* (L.), not *Myzus persicae* as was previously stated. *Rh. lactucellum* Theobald=*Myzus persicae* (Sulzer). *Saltusaphis africana* Eastop=*S. scirpi* Theobald. This species has now been seen from Egypt, Sudan, Kenya and South Africa.

197. Thanks are due to Dr. A. C. Evans and Messrs. B. Anderson and J. Hemingway for facilities and assistance at Nachingwea and to Mr. J. P. Doncaster similarly at the British Museum.

INSECTICIDE RESEARCH

K. S. McKinlay

198. Early in 1954 Mr. McKinlay moved from Uganda to join the Colonial Agricultural Insecticide Unit at Ilonga, Tanganyika Territory, of which he later assumed charge. The present report is an adaptation of one rendered by him to the Colonial Insecticide Committee. An arrangement has been made to transfer Mr. McKinlay to the service of this Unit, and no further reports on his work will appear in the E.A.A.F.R.O. Annual Reports.

199. Mr. P. Walker joined the Unit during November 1954 and has been carrying out insecticide field trials for the control of maize stalk borer in co-operation with Mr. G. Swaine, Tanganyika Government Entomologist. These trials were still in progress and results were not available at the time that this report was prepared.

200. The *Theraqtus* pest of coconuts was mentioned in the last Annual Report as one on which the Unit would work. However, due

to staff changes, this work has not been started; and future progress will largely be determined by the possible reorganization of the Unit and any arrangements that may be made for co-ordinating our work with that of other bodies concerned in coconut pest research.

201. Mr. Poulton joined the Unit during December 1954 and, while some of his time will be inevitably occupied by the routine duties of a Field Officer, it is hoped that the greater part will be spent in testing and developing spraying and dusting machinery suitable for use in the colonies. Much of this work will be done in co-operation with C.I.R., Arusha.

202. For various reasons the research work carried out during the year was limited to an extensive series of insecticide experiments for the control of cotton pests, carried out by Messrs. McKinlay and Jones on Ilonga Research Station. Valuable assistance was given by Mr. Valentine, Entomologist, Empire Cotton Growing Corporation.

203. A detailed account of this work has been written and is now awaiting publication; but, because of the light it throws on the use of insecticides in peasant agriculture, the more general aspects are discussed below.

(1) The principal cotton pests locally are several species of bollworm, principally *Heliothis armigera*, and Cotton Aphis, *Aphis gossypii*.

(2) These pests can be adequately controlled by weekly applications of 3% BHC/10% DDT dust at 10 lbs per acre.

(3) Endrin at ¼lb per acre gives slightly better control and offers the possibility of reducing costs by something like half when it becomes available commercially.

204. However, the discovery of the best insecticides, and frequency and rate of their application, are only a small part of the problem, and the use of insecticides on cotton is largely determined by the factors listed below.

(*a*) *Method of crop formation by cotton.* Work in America and by McKinlay in East Africa (awaiting publication) has shown that physical damage to the cotton plant by insects is not always represented by loss of yield. When planted early in a season of adequate rainfall the plant has a large capacity for compensating for the loss of fruiting points; and the use of insecticides to control what appears to be serious insect damage is not inevitably reflected by increased yield over that of untreated control plants.

(*b*) *Planting date*. Planting date affects the crop in two ways. Due to the rainfall distribution, planting date has a large effect upon yield and locally should be as early as possible to ensure the maximum yield. Secondly, the local bollworm attack on cotton arises from a build-up on maize planted as a food crop. The timing of this transfer of bollworm from maize is fairly consistent; and the earlier the cotton is planted the greater is the likelihood of a crop being formed before the bollworm attack develops.

(*c*) *Standard of Cultivation*. The standard of cultivation has a marked effect upon yield, and bad cultivation may easily reduce the yield of cotton to the point where the total yield is not sufficient to repay the cost of the insecticide alone.

205. The net effect of the interplay of all these factors in the local cotton crop, which is entirely peasant-grown, is roughly as follows. The native cotton in the Ilonga district is commonly interplanted with maize, is late-planted and gets only the minimum of thinning and weeding. The potential yield is often so low that, although the use of insecticides will show increases, agronomic factors may limit these to a point where the cost of applying insecticides is not recovered. Conversely early planting and good cultivation not only raise the potential yield to the point where the cost can be easily borne, but through earlier planting the worst of the bollworm attack may be avoided; and furthermore the costs of insecticide treatment may be lowered by shortening the period during which it is necessary.

206. In the light of this the belief in insecticides as a quick means of increased yields without changing the system of agriculture (Colonial Office, *Miscellaneous Publication No.* 519, p.8) may be founded on a fallacy. Certainly in the case of the local peasant crop the reverse would seem to be more correct. Insecticides are unlikely to show economically profitable increases in yield until the standards of native agriculture have much improved.

HORTICULTURE

W. B. May

207. The Muguga Plant Nursery now covers some five acres. Buildings include office, stores, frames and a small greenhouse recently added.

208. *Forestry Problems.* The main preoccupation of the staff of the Muguga Plant Nursery has been on practice in raising seedlings of forest trees. For convenience the results of many experiments on soil

mixtures, fertilisers, dates of sowing and pricking out and similar problems are reported in the section on Forestry. Other experiments, also reported under "Forestry", were on techniques for rooting pine cuttings, which were unsuccessful, and on grafting of pines and cypresses; the 1952 grafts have made strong unions and good growth of the scions. During the seven months when Mr. May was overseas, control of the Nursery was maintained by Mr. B. E. St. L. Stuart.

209. *Agricultural Problems.* Seed from several varieties of Citrus, provided by the Matuga Experiment Station of the Kenya Department of Agriculture, was germinated in 1953 with the intention of raising nucellar plants. It was hoped that virus-free stocks might be raised while retaining the qualities of the parent varieties. The seedlings proved unable to tolerate the Muguga climate and this project had to be abandoned.

210. Among miscellaneous activities have been the multiplication of several varieties of potatoes, on behalf of the Kenya Department of Agriculture, and of special types of lucerne and lupins for the Animal Industry Division.

SYSTEMATIC BOTANY AND ZOOLOGY

GENERAL

P. J. Greenway

211. The E.A.A.F.R.O. staff collaborates closely with the botanists of the Royal Botanic Gardens, Kew, who are entrusted with the production of the *Flora of Tropical East Africa*. Manuscripts of the families Caryophyllaceae and Menispermaceae were received for checking and general comments. Sections covering the families Alangiaceae, Canellaceae and Cornaceae for this Flora have been prepared by Dr. B. Verdcourt and submitted to Kew.

212. Owing to leave movements the staff had only limited opportunities for local field work during the period. In 1954 the Botanist-in-Charge spent seven weeks working at the Herbarium of the Royal Botanic Gardens, Kew, and the British Museum (Natural History), when many outstanding problems were cleared up and a paper on an ecological survey of Mt. Hanang, Tanganyika, finally completed. A further period was spent travelling by road from Cape Town to Nairobi during which visits were paid to botanical institutions in South Africa, the Southern Rhodesian Government Herbarium, Salisbury, the Agricultural Department's headquarters, Zomba, Nyasaland, the Forest Department, Ndola, Northern Rhodesia, and the Agricultural and Forest Department's headquarters in Tanganyika when many contacts were made or renewed. Plant collections were made at the Victoria Falls and elsewhere.

THE WORK OF THE EAST AFRICAN HERBARIUM

P. J. Greenway and B. Verdcourt

213. The E.A. Herbarium, housing the collections from the Amani Research Institute and the Coryndon Museum, in process of amalgamation, has remained under the administration of E.A.A.F.R.O., with the E.A.A.F.R.O. senior Botanist in charge. During the period under review three hundred accessions of specimens totalling over 5,400 for naming, 3,550 already named in exchange and 996 loaned for study, were received.

214. The more important of the unnamed collections were from:—

Ethiopia:—The Desert Locust Survey 635 specimens.

Kenya Colony:—The Agricultural Department, 197; Desert Locust Survey, 196; Education Department, 12; Forest Department,78; E.A.A.F.R.O., 572; E.A. Herbarium, 109; E.A.T.T.R.R.O., 47; Game Department (Fish Warden), 13; Pest Control (E.A.) Ltd., 152; Messrs. Grahame Bell, 57; Tsetse Survey and Control, Veterinary Department, 222; and others, including sundry private collectors, 243 specimens.

Tanganyika:—The Agricultural Department, 50; Colonial Insecticide Research, 314; E.A.A.F.R.O., 8; E.A. Herbarium, 73; Forest Department, including the Beekeeping Division, 2,006; Government Chemist, Chemical Laboratory, 21; Overseas Food Corporation, 113; E.A.T.T.R.R.O., 80; Veterinary Department and various private collectors, 72 specimens.

Uganda:—The Agricultural Department, 69; E.A. Fisheries Research Organisation, 31; Forest Department, 47; Makere College, 90 specimens.

Zanzibar:—The Agricultural Department, 3 specimens.

215. The named material totalling three thousand five hundred and fifty specimens was received in exchange from the following institutions :- The Botanisches Museum, Berlin Dahlem, Germany, 200; British Museum (Natural History), London, 113; Jardin Botanique de l'Etat, Brussels, 611; Royal Botanic Gardens, Kew, 1,868; Division of Botany and Plant Pathology, Pretoria, South Africa, 404; Department of Botany, University of Delhi, India, 101 specimens. The Kew donations are particularly valuable as they contain specimens collected by the Colonial Office Botanists, Messrs. J. B. Gillett, Drummond and Hemsley during their recent expeditions to East Africa.

216. Nearly eleven thousand specimens were distributed to botanical institutions overseas, including loan material of over three thousand sheets of Filices, Rhizophoraceae, Mimosaceae, Papilionaceae, Asclepiadaceae, Celastraceae, Anacardiaceae and Cyperaceae to the Royal Botanic Gardens, Kew, 125 *Erica* and Podostemonaceae to the British Museum (Natural History), London, for specialists to study for the *Flora of Tropical East Africa*. Over five hundred sheets of Apocynaceae were loaned to the late Dr. M. Pichon, Museum National d'Histoire Naturelle, Paris; 33 Amaranthaceae and *Geigeria* to the Botanische Staatssammlung, Munchen; 45 Rubiaceae to Dr. Bremekamp, Botanical Museum and Herbarium, Utrecht; 182 *Heliotropium* spp. to Mr. B. L. Burtt, The Royal Botanic Garden, Edinburgh; 168 *Dissotis* spp. to Prof. A. Fernandes, The Botanical Institute of the University of Coimbra, Portugal; 92 lichens to Dr. Carroll Dodge, Missouri Botanical Garden, St. Louis, and 223 *Eucalyptus* spp. to Mr. R. D. Johnson, Forestry and Timber Bureau, Canberra, Australia, to re-identify. The extensive collection of *Eucallyptus* in the E.A. Herbarium has now been examined by Mr. Johnson and thanks are due to him for working on our material of this very difficult genus.

217. Requests for plant material, both living and dead, continue and the following have been collected and sent:- to the United Kingdom, 29 samples of seeds, fruits and bark of Leguminosae, *Mitrogyna*, *Cupressus* and *Widdringtonia*, as well as spirit material; to Belgium, 6 samples of Leguminosae seeds; to U.S. America, 9 samples of *Conyza*, *Emilia*

seeds, *Rauvolfia* bark and soil samples from *Agave* and *Furcraea* roots; to Finland, *Hagenia* seeds; to South Africa, *Telfaria pedata* seeds and *Rauvolfia* bark; to Southern Rhodesia, *Lobelia giberroa* seeds; to Sweden, 67 pollen samples, and to Tanganyika, *Ambrosia maritima* seed.

218. Over five thousand three hundred specimens were named, and information supplied to government departments and correspondence in East Africa and elsewhere.

219. During the naming of collections and the amalgamation of the two herbaria 41 type specimens were found. The following new species were described from the Herbarium:—

Ancistrorhynchus tenuicaulis Summerhayes (Orchidaceae) in *Kew Bull.*, **1953,** p. 590. *Purseglove* 2044! isotype.

Chascanum gilletii Moldenke (Ver benaceae) in *Rev. Sudam. Bot.*, **6**, p. 18 (1939). *Gillett* 4934! isotype.

Corrigiola litoralis L. subsp. *africana* Turrill (Caryophyllaceae) in *Kew Bull.*, **1954,** p. 413. *Verdcourt* 663! isotype.

Cuscuta kilimanjari Oliv. var. *major* Verdcourt (Convolvulaceae) *l.c.*, p.42. *Purseglove* 2715! holotype.

Helianthemum somalense Gillett (Cistaceae) *l.c.*, p.493. *Popov* 1147! isotype.

Lobelia kinangopia Wimmer (Lobeliaceae) in *Pflanzenreich* **4,** 276, b, p. 777 (1953). *Verdcourt* 604! isotype.

Osteospermum afromontanum T. Norl. (Compositae) in *Svensk. Bot. Tidskrift*, **48,** 1, p.149 (1954). *Greenway* 7665! isotype.

Pavetta lindina Brem. (Rubiaceae) in *Kew Bull.*, **1953,** p. 504. *Eggeling* 6038! isotype.

P. yalaensis Brem. *l.c.*, p.501. *Gilbert Rogers* 741! isotype.

Pentas bussei Krause forma *brevituba* Verdcourt (Rubiaceae) in *Bull. Jard. Bot. Brux.*, **23,** p.302 (1953). *Musk* 144! holotype.

P. hindoioides K. Schum. var. *glabrescens* Verdcourt, *l.c.*, p.281. *Koritschoner* 631! holotype.

P. hindoioides K. Schum. var. *williamsii* Verdcourt, *l.c.*, p.279. *G. Williams* 66! holotype.

P. lanceolata (Forsk) Deflers subsp. *longituba* Verdcourt *l.c.* p.344 (1953) *Verdcourt* 710! holotype.

P. lanceolata (Forsk.) Deflers var. *membranacea* Verdcourt, *l.c.*, p.344. *Lindeman.* 817 ! holotype.

P. lanceolata (Forsk.) Deflers subsp. *quartiniana* (A. Rich.) Verdcourt var. cult. *alba* Verdcourt *l.c.*, p.349. *Verdcourt & Greenway* 279! holotype.

P. lanceolata (Forsk.) Deflers subsp. *quartiniana* (A. Rich.) Verdcourt var. *oncostipula* (K. Schum.) Verdcourt forma *velutina* Verdcourt, *l.c.*, p.353. *Greenway* 8462! holotype.

P. lanceolata (Forsk.) Deflers subsp. *quartiniana* (A. Rich.) Verdcourt var. *usambarica* Verdcourt *l.c.*, p.351. *Zimmermann.* 7877! holotype.

P. longiflora Oliv. forma *glabrescens* Verdcourt, *l.c.*, p. 286. *Napier* CM.10183! holotype.

P. parvifolia Hiern var. *intermedia* Verdcourt *l.c.*, p.305. *Verdcourt, Greenway & Brass* 200A! holotype.

P. parvifolia Hiern forma *spicata* Verdcourt *l.c.*, p.306. *Bally* 735! holotype.

P. purseglovei Verdcourt *l.c.*, p.329. *Purseglove* 1421! holotype.

P. zanzibarica (K1.) Vatke var. *intermedia* Verdcourt, (Rubiaceae) in *Bull. Jard. Bot. Brux.*, **23**, p.326. *Thomas* 3783! holotype.

P. zanzibarica (K1.) Vatke var. *latifolia* Verdcourt, *l. c.*, p.326. *Wallace* 983! holotype.

P. zanzibarica (K1.) Vatke var. *membranacea* Verdcourt, *l.c.*, p.323. *Eggeling* 6040! holotype.

P. zanzibarica (K1.) Vatke var. *pembensis* Verdcourt, *l.c.*, p.324. *Vaughan* 608! E.A. holotype.

P. zanzibarica (K1.) Vatke var. *rubra* Verdcourt, *l. c.*, p.322. *Greenway* 8467! holotype.

Peucedanum canaliculatum Verdcourt (Umbelliferae) in *Kew Bull.*, **1954**, p.40. *Greenway* 6927! holotype.

Pterocarpus usambarensis Verdcourt (Papilionaceae) in *Kew Bull.*, **1954**, p. 37. *Greenway* 6069! holotype.

Sphaeranthus greenwayi Ross Craig (Compositae) in *Hook. Ic. Pl.*, **36**, 3510 (1954). *Greenway* 4072! isotype.

S. mimetes Ross Craig *l.c.*, t. 3519 *Burtt* 3718! isotype.

S. napierae Ross Craig, *l. c.*, t. 3511. *Napier* 425! isotype.

Triumfetta shinyangensis Verdcourt (Tiliaceae) in *Kew Bull.*, **1954**, p.35. *Koritschoner* 1912! holotype.

Warburgia elongata Verdcourt (Canellaceae) *l.c.*, p.544. *Eggeling* 6813! holotype.

W. stuhlmannii Engler, neotype selected by B. Verdcourt in *Kew Bull.*, **1954**, p.542. *Gilchrist* 1! holotype.

W. ugandensis Sprague subsp. *longifolia* Verdcourt, *l.c.*, p.543. *Bryce* 1! holotype.

Zimmermannia acuminata Verdcourt (Euphorbiaceae) *l.c.*, p.39. Eggeling 6464! holotype *Semsei* 1279! paratype.

Z. grandiflora Verdcourt, *l.c.*, p.39. *Semsei* 676! holotype.

Zornia apiculata Milne Redhead (Papilionaceae) in *Bull. Soc. Brot.* **28**, p. 94 (1954) *Gillett* 13566! isotype.

Z. brevipes Milne Redhead *l.c.*, p.98. *Davies* 183! isotype.

220. These thirty-nine new taxa, together with the forty-one recently found, now brings the total number of known types in the Herbarium up to 765.

221. A total of 11,007 specimens were filed into the Herbarium in the course of the year, including 2,007 sheets comprising 24 families from the Coryndon Museum, 870 from the Vaughan Collection and 635 grasses, bringing the grass collection up to 10,126 sheets and the grand total for the Herbarium of 95,490 specimens. Books were loaned, lists of plants and separates of papers were supplied on request, and seven photographs of giant *Senecio* and *Lobelia* spp. given to Kew.

222. Work on the amalgamation of the Coryndon Memorial Museum Herbarium continued only spasmodically owing to interruptions by other more important work; but as already stated twenty-four families including the Papilionaceae and Filices were dealt with.

ZOOLOGY

B. Verdcourt

223. A very large proportion of the voluminous and exceedingly scattered literature on the non-marine mollusca of Eastern Africa has now been either obtained or abstracted and work has commenced on the long term task of compiling a check list. An article on East African Cowries and a supplement have now been published.

224. A considerable number of mollusca have been named for various departments and private individuals. The publication of Dr. Mandahl-Barth's book on the freshwater molluscs of Uganda should be a valuable aid to the medical departments of the various territories.

225. Further material including yet more new species of *Meligethes* has been sent to Dr. Easton and he will soon be in a position to prepare an account of the material collected during the past five years. A very interesting new weevil of the genus *Antliarrhinus* was bred from material of an *Encephalartos* (also new) sent from the Matthews Range. This genus of weevil was hitherto unknown outside South Africa, previous northern records being erroneous.

FORESTRY

A. L. Griffith

226. The period of this report includes two planting seasons and hence the results of two years of experiments. Work has continued on the long-term lines described in the 1952 Report. Particular attention has continued on softwood problems, to the development of Muguga estate for nursery, short-term and long-term experimental work and on building up the information section.

227. The Silviculturist in charge was on leave for 6½ months and the Horticulturist on secondment to Northern Rhodesia and on home leave for a similar period. In consequence a heavy burden of work fell on Mr. B. E. St. L. Stuart, who carried it with notable success.

228. During the period the Silviculture Specialist Committee came into being as a simplification of the Specialist Committee on Forest Research, which last met in 1950. The first meeting of this new Committee was held in Uganda in November 1954 and a second at Muguga in March 1955. Arising from these meetings plans were developed for interterritorially replicated experiments on (*a*) fertiliser application in forest nurseries, (*b*) short-term planting out experiments, (*c*) the effect of the season of pruning on the rate of wound occlusion (this may have a large effect on disease incidence) and (*d*) the selection at an early age of the final crop trees in a plantation, by a method evolved in Queensland, Australia.

I. INFORMATION SERVICES

229. The Bureau was maintained and expanded and now contains 1687 Specific Ledger Files and 767 General Ledger Files. The E.A. Forest Bibliography has gone to the printer. This work has taken much longer than was anticipated owing to difficulties of access to many of the publications listed.

230. During the period a series of E.A.A.F.R.O. Forestry Technical Notes was inaugurated, the first three being No. 1 "Nursery Notes to Remember" by W. B. May, No. 2 "Seed Weights for Tree Species Commonly Grown in East Africa" by B. E. St. L. Stuart, and No. 3 "Fertilisers and Forestry" by W. B. May.

II. STANDARDISATION OF RESEARCH PROCEDURE

231. As a result of the work of the Silviculture Specialist Committee, in conjunction with the E.A.A.F.R.O. Statistician, notes were sent to the territories on possible techniques for experiments on single trees (as opposed to plots) and on sampling for diseases and pests where they cannot be detected without felling the tree and where, therefore,

for practical reasons only small numbers of trees can be felled for the purpose.

III. RESEARCH ON SOFTWOODS

232. This report covers investigations at Muguga in which Dr. A. L. Griffith, Mr. B. E. St. L. Stuart and Mr. W. B. May have collaborated.

A. Seed Problems

233. (*a*) *Cupressus lusitanica progeny trials.* The three plots planted out in 1952 with stock raised from seed of selected Elburgon (Kenya) seed and separated into groups of 2-, 3- and 4-cotyledon seedlings were remeasured at the end of March, 1955. The differences in height growth, which were after 1 year in favour of the 4-cotyledon type, are now slightly in favour of the 2-cotyledon type. There is no discernible difference in habit or vigour between the groups; but there is great variation in form and colour between individual trees, which may be attributed to hybridisation. These plots were a pilot experiment and have been replaced with further sets of plots, now 1 year old, comparing the growth of (1) stock from 5 different sizes of seed from each parent tree, (2) stock from 3 different cotyledon numbers (2, 3, and 4) from each parent tree.

234. (*b*) *Seed orchards.* Attempts at grafting during 1953 were a failure. This is attributed to the almost unbroken hot dry weather. Further attempts in 1954 were disappointing, again a difficult year climatically owing to abnormal rain in April. The few successful grafts of 1952 continue to do well. These show that cypresses can be grafted on to cypresses and pines on to pines under our conditions.

235. In 1954 the Silviculturist visited Forest Genetic and Tree Breeding stations of Scandinavia to study their tree-seed orchard work. It appears to hold great promise for East Africa once the technique has been worked out. The Silviculturist gave a talk on the Scandinavian work and its possibilities in East Africa to the Nairobi Scientific and Philosophical Society in March, 1955.

B. Nursery Problems

236. It was not possible to hold a third Nursery Course in 1954 and this is planned for November, 1955. The first two courses were attended by 34 forest officers and foresters from Kenya, Uganda, Tanganyika and Zanzibar.

237. Experimental work in the nursery at Muguga has continued. An account of the results of the 1953 and 1954 experiments and their bearing on the work of 1951 and 1952 is given below. In a number of cases the results so far are not consistent and much further repetition is required. In part the inconsistencies may be due to the very varied weather experienced. Only 1952 with 36.6 inches gave rainfall near to the average; 1951 and 1954 (57.3 and 47.4 inches) were above average and 1953 (22.5 inches) well below. So far 1955 has been very deficient in rainfall.

238. *Alteration of the pH of the soil.* Further work on this subject was not done as previous work covering 4 species (*C. lusitanica*, *P. radiata*, *P. patula* and *P. engelmanni*) over 2 years had conclusively shown no advantage from the use of either lime or acid.

239. *Soil Mixtures.* The pilot work of 1951 has been continued during the past 3 years to compare the results obtainable with 4 balanced soil mixtures as compared with 3 local soils used without modification. From the work of 1951 and 1952 we evolved a Muguga Standard Mixture (which we consider an improvement on the mixtures previously used) and in the experiments of 1953 and 1954 this has also been used both with and without the addition of a small basic quantity of NPK. This "basic" NPK consists of N, P and K in the ratio of 3: 3: 1 and used at the rate of 3 oz. per sq. yd. of bed or ½ oz. per box of approximately 50 plants. Its use is merely to ensure that the basic nutrients are present.

Muguga Standard Mixture contains:—	
Forest Soil	5 parts.
Clay	1 part.
Peat	2 parts.
Rotted horse manure	1 part.
Crushed stone	1 part.

240. The species used were: 1952 *P. patula*, *P. montezumae* and *P. engelmanni*, 1953 and 1954 *P. radiata* and *P. patula.* The general indications from these experiments are:—

(*a*) Our soil *in situ* which has been under wattle for many years is very poor and any form of mixture has given better results.

(*b*) The use of unmodified pine soil or forest soil, although giving in general better growth than our local soil, has been very variable in results.

(*c*) Muguga Standard Mixture with or without the basic application of N.P.K. has given us not only an average increase in

height growth of over 60 per cent but this increase has been very consistent. This is above all what is required in a forest nursery.

(*d*) Survival percentage throughout these experiments with all species and all types of soil has been very consistent and generally high, the range being from 89 to 95 per cent.

(*e*) Of our two main species *P. patula* is much more sensitive than *P. radiata* and gives a very much greater response, an average increase of height growth with Muguga Standard Mixture of 85 per cent as compared with the 42 per cent of *P. radiata*.

241. *Pine soil experiment.* This experiment to determine whether the use of soil from pine plantations is necessary in pine nurseries was continued in 1953 and 1954 with *P. patula* and *P. radiata*. For comparison of the results with those obtainable from a good balanced soil mixture, two extra treatments (Muguga Standard Mixture with and without basic NPK) were added in 1953 to the 4 treatments of the experiment started in 1952. The inclusion of N and P treatments (as in 1952) was considered an unnecessary complication, since fertiliser responses were adequately catered for in separate experiments (see para. 244—247 below). The general indications of these experiments over 3 years are that Muguga Standard Mixture, a good balanced soil without any "pine inoculation", has produced better plants and that pine-soil inoculation in Muguga nursery is probably not necessary. It is the soil structure and the soil nutrients that have the greater effect. Again *P. patula* is much more sensitive than *P. radiata* and with Muguga Standard Mixture in 1953 and 1954 produced a response of + 73% as compared with + 41% of *P. radiata*. It must, however, be remembered that we have so far not been able to determine the bacterial or fungal contents of the soils used.

242. *Comparison of different pine soils.* The result of the pine soil experiments above prompted an experiment in 1954 to endeavour to compare the results obtained with pine soils from under the oldest pine plantations of different species and from different places. The soil used was that of the first 3 ins. of the forest floor below the undecomposed litter from *P. patula* and *P. radiata* stands at Kinale and Kitiro. Survival percentages were high and varied from 86% to 100%. This experiment needs repetition but so far indicates that the two species used do not show preference for their "own" soils (i.e. for possibly specific mycorrhizae), at any rate under Muguga conditions, but that the 4 soils used were merely of different qualities. It is unfortunate that in this experiment no comparison was made with Muguga Standard

Mixture without any pine-soil ingredient. Again the greater sensitivity of *P. patula* is seen in that its response with the best soil compared with that with the poorest soil was + 102% as compared with + 26% of *P. radiata.*

243. "*Mycorrhizal brew*" *experiment.* In order to test the possibilities of mycorrhizal inoculation an experiment was started in 1954 in which soil from unwanted boxes of *P. patula* and *P. radiata* were accumulated separately and added to the extent of 5% to Muguga Standard Mixture boxes in which *Pinus patula* was grown. This first experiment indicates that:—

(*a*) No deleterious effect has resulted from the "brew".

(*b*) That little, if any, benefit has resulted from the addition of the "brew".

(*c*) There is no indication that *P. patula* prefers a *P. patula* "brew" to a *P. radiata* "brew". The range of heights between treatments is no greater than we get between boxes of ordinary stock, such as the control boxes in fertiliser experiments.

244. *Fertilisers.* The experimental work on NPK applications begun in 1951 was continued. The same fertilisers were used, namely sulphate of ammonia, triple superphosphate and sulphate of potash. Four separate experiments were laid down in 1953 using the same fertiliser rates as the 1952 experiments; *viz.*

Fertiliser rate 5.	Ammon. Sulphate, 540 lbs. per acre (8 gms. per box). Superphosphate 540 lbs. per acre (8 gms. per box). Pot. Sulphate, 270 lbs. per acre (4 gms. per box.)
Fertiliser rate 10.	Twice the above quantities.

These rates are respectively 5 and 10 times the rates originally used in the initial experiment of 1951. In all 4 experiments all possible combinations of the 2 levels of N.P. and K. were tried. The species grown was *P. radiata.* The experiments were:—

Expt. N.1/1953.	Muguga Standard Mixture. Fertiliser applied 6 weeks after pricking out.
Expt. N.2/1953.	Muguga Standard Mixture without basic N.P.K. Fertiliser applied 6 weeks after pricking out.
Expt. N.3/1953.	Muguga Standard Mixture without basic N.P.K. P. and K. applied before pricking out. N. 6 weeks later.
Expt. N.4/1953.	Muguga Standard Mixture without basic N.P.K. All fertilisers applied before pricking out.

The first two of the above are comparable with the 1952 experiment with *P. radiata* in which fertiliser was applied 6 weeks after pricking out. Expt. N. 2/1953 was an exact repetition. Expt. N. 1/1953 only differed in that the small "basic" N.P.K. application was included in the mixture. Four parallel experiments were done in 1954 with *P. patula,* treatments

being identical with those of the 1953 experiments. A further series of experiments were carried out with Muguga Standard Mixture (without the addition of basic N.P.K.) and fertiliser applications at different times before and after pricking out.

245. Survival percentage in all the experiments was generally good. All these fertiliser experiments show the same general trends but the responses vary in degree according to the climatic year. The general indications from them are:—

(*a*) The degree of the response to the fertilisers varies according to the type of climatic year, being greater (about 33%) in a normal to wet year than in a dry year (about 10 to 15%).

(*b*) There is very little difference in response between the "5" and "10" rates of application and hence the latter rate is unnecessarily high.

(*c*) The effect of the application of fertiliser 12 weeks after pricking out is very small compared with application 6 weeks after pricking out.

(*d*) In the 1953 experiments in which P. and K. were applied before pricking out, the application of N. 6 weeks after pricking out, was rather more beneficial than its application before pricking out. The opposite result was obtained in the 1954 experiments. This is possibly the differing effects of a dry and a wet year.

(*e*) The general result of the fertiliser application is that N. is the most important, with P. in second place and K. in third place, but that the application of all three fertilisers produces the largest response.

(*f*) These and the other experiments already mentioned show that the application of a basic quantity of N.P.K. is a very worthwhile insurance. The quantity used is small, 3 oz. per sq. yd. of bed or ½ oz. per box of approximately 50 plants, but it ensures that the basic nutrients are present.

246. *Date of sowing.* The experimental work started in 1952 to determine the effect of different dates of sowing on the resulting plants was continued. Sowings of *P. Patula*, *P. radiata* and *C. lusitanica* are now being made every month. The seed available (and hence the sowings) was periodic in 1952 and the early part of 1953. The stock raised is planted out in about April each year in short-term experiments to observe the subsequent behaviour of the various sizes of stock (see C. below).

247. The experiments show a big drop in height growth between pre-long-rains and post-long-rains sowings. Survival percentage appears to drop for August to October sowings, this effect being most marked

with *P. patula.* With *C. lusitanica* and *P. radiata* mean height growths of about 12 to 14 ins. and of about 12 to 13 ins. respectively can be obtained with post-long-rains sowings and, although short-term planting out experiments may show that larger plants do better, plants of this size have been satisfactory in the field in short-term planting out experiments. The need for larger transplants of these two species appears to be less than for example with some of the other pines such as *P. patula*, which are more sensitive to handling especially if small and soft stemmed. With *P. patula* there is a great difference between pre-long-rains and post-long-rains sowing, and with the latter it does not appear that we can produce a plant of more than about 8 ins. in one year. With this species, if we want bigger plants we shall either have to do pre-long-rains sowing, which greatly increases the nursery size and nursery costs, or we must find some other treatment such as possibly wider spacing, use of shade, fertilisers, deep beds etc. It is to be noted that the average size of 8 ins. produced in one year with *P. patula* is a very great advance over the practice of 4 or 5 years ago.

248. *Effect of spraying with a gum solution or a wax emulsion to reduce transpiration in dry planting.* An experiment was done in 1953 in which transplants of *P. radiata* and *P. patula* were sprayed with various concentrations of gum arabic solution to endeavour to reduce transpiration when planting in dry weather. The experiment was repeated in 1954 with "Ceremul" wax emulsion. In neither of the experiments did any of the treatments materially help the plants. The larger plants irrespective of treatment survived better than the smaller ones.

249. *Effect of time between germination and pricking out on subsequent growth and survival.* Argument still continues on the period that should elapse between germination and the pricking out of seedlings in the nursery. An experiment was begun in September 1953 in which seedlings of *C. lusitanica*, *P. patula* and *Eucalyptus saligna* were pricked out from the same seed beds 2, 5, 8, 11, 14, and 17 weeks after germination. In this experiment really early pricking out (as early as 2 weeks after germination) produced the best results; and, in general, the longer the delay, the greater the check and the poorer the subsequent growth. A repeat experiment in 1955 is not yet sufficiently advanced for any assessment to be made.

250. *Use of wood preservatives on transplant boxes.* Experiments were done in 1953 and 1954 (*a*) to study the lasting qualitity of transplant boxes treated with 3 different preservatives and (*b*) to determine whether any of the preservatives used have adverse effects on the growth of trees planted in the boxes. The preservatives used were "Celcure",

P.C.P. (pentachlorophenol) and "Blundwood" (a creosote preservative). In 1953 P.C.P. appeared to have an adverse effect on the height growth of *P. patula*, coupled with a yellowing of the plants, and also on the survival percentage of *P. radiata*. But in 1954 none of the preservatives used had any appreciable effect on the plants. This effect may have been climatic as 1953 was a dry year and 1954 an average to wet year.

The 1953 boxes were again used in 1954. One Celcure/*Grevillea* box and one P.C.P./Cedar box were not fit to use. All the surviving boxes are in much the same generally fair condition but it is doubtful if they will last for a third year.

251. *Use of soil blocks for transplants.* In 1953 stock of a number of species was raised in soil blocks, to compare them with stock grown in boxes and beds. Equally good stock was obtained in the blocks, but it proved necessary (*a*) to stand the blocks on boards to prevent rooting into the ground, and (*b*) to cover the blocks with a mulch of shavings to reduce drying out during-the dry season. By April 1954 blocks which had been in use longer than 6 to 8 months were beginning to disintegrate, owing mainly to heavy watering in a dry year. This method of raising stock therefore only seems suitable for the quicker-growing species.

252. *Use of a proprietary soil conditioner.* Experiments were done in 1953 and 1954 to test the effect of a soil conditioner on transplants grown in three types of soil. The soils used were (*a*) Mount Meru (Tanganyika) volcanic soil which is very fine and of poor structure, (*b*) Muguga Standard Mixture and (*c*) Muguga soil *in situ* (ex wattle). One set of boxes of each soil type was treated with 14 gms. of the conditioner per 30 lbs. of dry soil, the other set being left untreated. The species used were *P. radiata* in 1953 and *P. patula* in 1954. Results showed that the addition of the conditioner produced no apparent benefit and also no deleterious effect in any of the treatments. The best results were obtained with both species with Muguga Standard Mixture without any admixture.

C. *Short-term Planting out Problems*

253. The year 1953 saw the start of short-term experiments to compare different establishment techniques. These experiments were started in the long rains and as far as possible 100 plants per treatment were used. Eighteen experiments were done in 1953, 36 in 1954, and 20 started in 1955. The results, summarised below, are only tentative as the experiments must be repeated for a number of years in order to cover the climatic range.

254. *Planting stock from different dates of sowing in the nursery.* (2 experiments in 1953, 3 experiments in 1954.) With *P. patula* three sizes of plants were put out (*a*) 9 to 12 ins., (*b*) 5 to 8 ins., and (*c*) under 5 ins. Measured after a year, the increment and vigour of the largest plants was the best, but except with the smallest plants, survival percentage was generally good. In present circumstances the normal size of plants raised in 1 year is only about 8 ins. and if we wish to use larger plants than this either we must improve our nursery technique or be prepared for the extra cost of the longer period in the nursery.

255. Three size-classes of *P. radiata* were put out in 1954, (*a*) over 13 ins., (*b*) 7 to 12 ins., and (*c*) 3 to 6 ins. The general indications from this one experiment are that, within the range of heights used, in general the bigger the plant the better its growth and development. Survival percentage was good (over 90%) for all sizes. The size of the plant put out drops markedly the later the sowing, and in a wet year long-rains sowing in the nursery may be unsatisfactory. As is seeen in para. 247 above, pre-long-rains sowings have resulted in plants of about 18 to 21 ins. and post-long-rains sowings in plants of 12 to 14 ins.

256. With *C. lusitanica* the sizes resulting from the monthly sowings could be grouped as (*a*) 19 to 24 ins., (*b*) 13 to 18 ins., (*c*) 7 to 12 ins., and (*d*) 3 to 6 ins. Survival was generally good (98% and over) except for the smallest sizes. The general indications from these 2 experiments are that within the range of heights used, the bigger the plant the better its height growth and general vigour. If plants of less than 6 ins. are used, survival is likely to be greatly reduced. From para. 247 above it is seen that planting stock of 12 to 13 ins. can be produced by post-long-rains sowing. The height growth and survival of stock of this size was satisfactory when planted out in short-term experiments and little less than the considerably older and larger stock used. With this species there appears to be no necessity for pre-long-rains sowing under these conditions.

257. It should be noted that in these experiments the planting out was done by dates of sowing (*vide* paras 246 et sec.) but the general results are expressed in terms of height classes as being more practicable to consider.

258. *Different dates of planting.* (1 experiment in 1953 and 2 experiments in 1954.) There were 3 fortnightly plantings in 1953 with *P. patula* and 7 weekly plantings in 1954 with *P. patula* and *C. lusitanica.* These experiments need considerable repetition but at present show that planting in dry soil 8 days before the rains broke was a failure, while planting in dry soil the day before the rains broke was a success. So

far it would appear that with *P. patula* the earlier it is planted, the greater the growth and development. This is far less marked with *C. lusitanica* and there appears to be very little advantage to be gained by risking too early planting. Height growth and survival percentage, however, markedly drop with late planting.

259. The experiment has been repeated in 1955, and at each date of planting an estimate of the depth of wetting of the soil was made. For each date of planting also the actual amount of rain that has fallen since an arbitrary date is being noted and also the rainfall "build up", allowing for evaporation on dry days, is being calculated (in accordance with suggestions made by Dr. Pereira). By next year we should therefore have a much more complete picture of the implications of the results of these experiments.

260. *Different sizes of stock from the same date of sowing.* (3 experiments in both 1953 and 1954.) The sizes of stock used in these six experiments range from 2 inches to 20 inches: the species used were *P. montezumae*, *P. patula*, *C. arizonica* and *C. lusitanica*. In all the experiments the larger sizes at planting remained larger and more vigorous at the end of one year. There was, however, little difference in survival except with the smallest plants. It must be remembered that the experiments were done under experimental garden conditions. In field conditions the chances of heavy casualities with the smaller sizes through weeds, competition of field crops, or of being overlooked or trampled in tending operations, would be very much greater.

261. The experiments show the great advantage to be obtained by culling the runts and only using the best plants; for at the end of the first year the runts were still the runts, and, even if alive, under field conditions would have cost considerably more in tending and the plantations would not be even.

262. *Comparison of sowing, transplanting and stump planting.* (3 experiments in 1953 and 7 in 1954.) In these experiments the treatments compared were:—

(*a*) Transplants (ex boxes or beds).

(*b*) Stumps from stock grown in open beds, planted at once, and after 3 days storage.

(*c*) Direct sowing of 10 seeds per stake except for the small-seeded *Eucalypts* when a "pinch" of about 200 seeds was sown.

Although this is only the start of this series of experiments indications so far are:—

Eucalyptus salinga. Transplanting is by far the best method.

Fraxinus americana and Fraxinus pennsylvanica var. *lanceolata.* Transplants do best but growth is poor. The species does not appear to like Muguga.

Ulmus parvifolia. Transplants and stumps both survived well but growth was poor. Bigger stumps might have done better.

Ulmus pumila. Stumps were good but growth poor. Larger stock might have done better.

Maesopsis eminii. The best treatment was that of 2 to 3 ft. transplants which were cut back to 18 ins. before planting because of damage to the roots on lifting. Its general appearance is poor probably due to the unsuitability of the climate and altitude of Muguga. The reason for the total failure of stumps is not known.

Robinia pseudo-acacia. Stump planting was the best method of raising this species. Direct sowing germinated well but did not survive. We are finding this a difficult species to raise in Muguga and stumps from bigger and better stock must be tried.

263. *Comparison of direct sowing and transplanting for pines and cypresses.* (2 experiments in 1953 and 3 in 1954.) With all three species, *P. patula*, *P. radiata* and *C. lusitanica*, transplanting was by far the most successful method of raising these species. Although quite fair germination resulted from direct sowing the survival percentage and height growth were very poor indeed.

264. *Comparison of planting stock raised in different nursery soils.* (2 experiments in both 1953 and 1954.) In the 1953 experiments the stock planted out was that from nursery experiments in which the stock was raised in 4 soils:—

(*a*) 100% pine soil.
(*b*) 50% pine soil, 50% forest soil.
(*c*) 100% indigenous forest soil.
(*d*) 100% local *in situ.*

In 1954 two further treatments were added, (*e*) Muguga Standard Mixture and (*f*) Muguga Standard Mixture without basic N.P.K. Preliminary indications are that treatments scarcely affected survival percentage which was generally high throughout. There was little to choose between the first 4 soils, but in the 1954 experiments the plants raised in Muguga Standard Mixture both with and without basic N.P.K. maintained the advantage in height growth that they had gained in the nursery up to the end of the first year after planting out.

265. *Planting stock raised by different box and bed techniques.* (1 experiment in 1953 and 1954.) Species *P. patula.* These experiments compared stock raised by different methods, as follows:—

(*a*) Grown in boxes.
(*b*) Grown in "Swaziland" beds and root-pruned with piano wire.
(*c*) Grown in open beds without undercutting the tap root.

The stock from the treatment (*c*) was divided into 2 batches one being lifted with as much of the taproot as possible and retaining as much soil round the roots as possible, the other being lifted, the soil removed and the taproot cut to 4" length.

266. At the time of planting the heights of the plants were approximately (*a*) and (*b*) 5 to 7½ ins., and (*c*) 8 to 16 ins. After 1 year the smaller stocks (*a*) and (*b*) have made up a good deal of leeway but were still smaller than (*c*). Survival in (*c*) was unexpectedly good with the taproot cut, but not as good as (*a*) or (*b*) which showed 88 to 100% survival.

267. The degree of success achieved with open beds suggests that slightly less rudimentary treatments might be possible. A modified Swaziland bed technique in which the beds were deeper and the plants wider spaced seems likely to be satisfactory, since the resulting larger stock will probably stand much rougher treatment in the field.

268. *Comparison of 4 methods of raising Araucaria cunninghamii.* This is an important softwood species that is said in Australia to be best raised in tubes, as it is strongly tap-rooting and does not like root interference. In Queensland the technique used is to prick it out into metal tubes; but in India it was transplanted normally.

269. In 1954 treatments used for a planting out experiment were:—

(*a*) Stock raised in transplant boxes.
(*b*) Stock raised in felt tubes about 8 ins. long, the taproots being cut on pricking out into the tubes.
(*c*) As (*b*) but taproots not cut on pricking out into the tubes.
(*d*) As (*b*) but the cut ends of the roots treated with Seradix B1 before pricking out into the tubes.

At the time of planting the felt tubes were much decayed and in consequence treatments (*b*), (*c*) and (*d*) were planted out in their tubes. Also the boxed plants were not apparently poorer than those in the tubes.

270. After 1 year of the experiment the general survival was good (96% and 100%) and there was little difference in height growth between any of the treatments. The roofiing-felt tubes as tried would not be satisfactory for raising stock on a large scale, as they are expensive and not sufficiently durable to be used a second time.

271. *Comparison of different sizes of planting holes.* (2 experiments in both 1953 and 1954.) Species *P. patula* and *C. lusitanica.* In these experiments plants from the same stock were planted in holes about (*a*) 6 by 6 by 6 ins., and (*b*) 12 by 12 by 12 ins. In all experiments both treatments had done equally in height growth and survival percentage. It is possible, however, that in hard compacted soil large holes might be advantageous.

272. *Comparison of stock grown in boxes, beds and in earth blocks.* (1 experiment in 1953 with *Eucalyptus sideroxylon* and 1 in 1954 with

Eucalyptus saligna.) In this experiment stock raised in the nursery from a sowing in (*a*) boxes, (*b*) "Swaziland" beds (root-pruned) and (*c*) earth blocks was planted out. After 1 year in both the experiments there was little to choose between treatments in height growth, survival percentage and vigour, although with *E. sideroxylon* there was a slight indication that the growth of plants raised in earth blocks was a little faster in the first year. In view of the excellent results obtained with the less cumbersome and less expensive methods of boxes and beds both in 1953 (a dry year) and in 1954 (a normal to wet year) there appears to be no advantage in using earth blocks under Muguga conditions.

273. *Comparison of different dates for direct sowing*. Three experiments were done in 1954 with *P. patula*, *C. lusitanica* and *Eucalyptus saligna*, in which sowing was done in 5 weekly sowings starting on March 12th. Height growth and survival percentage was extremely poor for all species after 1 year and there was little appreciable difference between the results of the different sowing dates.

274. *Comparison of different depths of planting*. Two experiments were done in 1954 with *P. patula* and *P. leiophylla* in which plants from the same stock were planted (*a*) at the collar, (*b*) 2 ins. above the collar, and (*c*) 4 ins. above the collar. The deep planting did not have any appreciable effect on survival or vigour except for a slight reduction with the deepest planting of *P. patula*. This was in a year of heavy rain followed by drier conditions than usual. Height growth also was not adversely affected by the deep planting. This practice, if proved reliable, might be beneficial under conditions where droughts are experienced, for they tend to get the root systems down more quickly out of the upper layers of the soil. This experiment needs much repetition for reliability.

275. *Effect of application of fertiliser at planting time*. Two experiments were done in 1954 with *P. patula* and *P. radiata* . The treatments were:—

(*a*) Controls. No fertiliser.

(*b*) Inorganic fertiliser. ½ oz. N.P.K. made up in bulk in the proportions 3: 3: 1 and mixed with the soil in the pit before planting each plant.

(*c*) Organic fertiliser. 1 oz. of N. + P. (½ oz. each) made up in bulk and mixed with the soil in the pit before planting each plant. The N was 50% dried blood and 50% hoof and horr and the P was steamed bone meal.

No conclusions can be drawn from one years results but the fertilisers had no appreciable effect on the mean height growth after 1 year. There was an indication that the fertilisers slightly reduced the survival percentage.

276. *Comparison of bare-rooted and ball-planted transplants.* Two experiments were done in 1954 with *P. patula* and *P. radiata* raised in boxes. One set of plants was cut out of the boxes in the normal way at the planting site, earth being retained as far as possible round the roots. The other set was cut out of the boxes, the roots were shaken free of soil, bundled, wrapped in a damp sack, and taken to the planting site.

277. No conclusions can be drawn from one year's results, particularly as 1954 was a year of heavy long rains and planting was done under exceptionally favourable conditions. There was no appreciable difference in either mean height growth or survival percentage between the treatments.

278. *Comparison of different weeding methods.* An experiment was started in 1953 and repeated in 1954 with *P. patula*. The ground was initially clean after felling a wattle stand. Treatments were in blocks and the espacement was 6 by 6 ft. Treatments were (*a*) clean weeded, (*b*) spot-weeded with the spots 3 ft. in diameter and (*c*) left unweeded. In the last two treatments there was heavy natural regeneration of wattle and this was periodically slashed.

279. These experiments demonstrated the very beneficial effects of weeding, and showed that even clean weeding in 3 ft. diameter circles seriously retards the plants in height growth and survival. At the end of the first year the retardation in height growth for the spot-weeded and unweeded treatments was 30% and 35% and at the end of the second year was 45% and 61%. With regard to survivals the correspondign depressing effects were 13% and 22% at the end of the first year and 17% and 38% at the end of the second year.

280. Further to study the serious effects of weeds and to give a general picture, temporary plots were measured in the 1953 plantation of *P. patula*, *P. canariensis* and *C. lusitanica* which had been strip weeded for 2 years. Couch grass (mainly *Digitaria scalarum*) had come into parts of the area in spite of the strip weeding. After 2 years, invasion by grass had reduced height growth by 30% and survival by 16%.

281. Another comparison made was that of 3-year old *C. torulosa* grown in a clean-weeded plot with trees that had been grown in 5 ft. diameter clean-weeded circles in Kikuyu grass (*Pennisetum clandestinum*). The reduction in height growth after 3 years, even with such quite large clean weeded circles, was 44 per cent.

282. A field experiment has been started in 1955, in conjunction with the Soil Physicist, to study the effect of (*a*) shamba crops and (*b*) cultivation on the height growth and survival of *P. patula*.

D. Long-term Problems

283. An experiment has been started in 1955 to determine the effect of season of pruning on the rate of occlusion of wounds on *C. lusitanica*. This is part of a series of interterritorially replicated experiments based on the indications so far given by Kenya experiments.

284. About 17 acres mainly of *P. patula* were planted in 1953, 5 acres each of *P. montezumae* and *P. leiophylla* in 1954 and 6 acres of *P. radiata*, 6 acres of *Cryptomeria japonica*, 3 acres of *Cupressus benthamii*, and 2 acres each of *P. patula* and *P. caribaea* in 1955 in order to provide material for future experiments.

E. Trials of species (mainly exotics)

285. The arboretum of small trial plots was again expanded in 1954 and 1955 and now consists of 115 plots. These include:—

Eucalypts	37 plots (35 species).
Pines	22 plots (22 species).
Cypresses	16 plots (14 species).
Callitris	3 plots (3 species).
Widdringtonia	4 plots (4 species).
Acacia	6 plots (6 species).
Various	27 plots (27 species).

286. *Comments on the 1952 plots.* (at 3 years old.) *Cupressus benthamii* is the tallest cypress (15 ft. 6 ins. top height.) *C. lusitanica* (Kenya seed) shows much variation between individuals including some fasciated and deformed types. *C. macrocarpa* (top height 13 ft. 6 ins.) has already suffered several fatal casualties from the *Monochaetia* canker and many more trees in the plot are infected. There is slight but apparently not serious infection in the *C. lusitanica*. *P. radiata* and P. *canariensis* are the tallest pines with a top height of 12 ft., followed by *P. halepensis* and *P. patula* at 10 ft. *Hagenia abyssinica* (9ft.) is surprisingly good for the low altitude and rainfall of Muguga, and is a completely closed crop with a clean floor. Local *Eucalyptus saligna* is very fast at 33 ft. 6 ins., and it remains to be seen how it compares with *Eucaly-*

ptus saligna of Australian seed origin now 24 ft. at 2 years, and *Eucalyptus grandis* (Australian origin and now 11 ft. 6 ins. at 1 year old), and *Eucalyptus saligna* of S. Africa origin (now 10 ft. at 1 year old). *Syncarpia laurifolia* has grown rapidly, 13 ft. 6 ins., but its form is poor. *Grevillea robusta* (15 ft. 6 ins.) has a poor form and shows a pronounced tendency to lean on account of the wind.

287. *Comments on the* 1953 *plots.* (at 2 years old.) All the Eucalypts have grown fast, *E. viminalis* and *E. botryoides* both reaching 26 ft., while *E. punctata*, *E. muelleriana*, *E. maidenii*, *E. macarthuri* and *E. resinifera* were all over 20 ft. top height. *E. viminalis* and *E. punctata*, both of which are being tried as timber species, as opposed to fuel and pole species, are seriously wind blow and of poor form. Of the pines *P. taeda* (8 ft. 6 ins.) *P. leiophylla* (6 ft. 6 ins.) and *P. montezumae* (6ft.) have so far done best. *P. clausa* (6 ft. 6 ins.) still looks unhappy and rather yellow. *P. echinata* and *P. virginiana* are very poor and *P. engelmanni* still remains healthy but in the "grass" stage at about 6 ins. high. *C. lindleyi* (S. African seed origin) is 10 ft. top height and looks well with very little variation between individuals. *Araucaria angustifolia* looks very sturdy and is 4 ft. 6 ins. Of the tan-bark acacias *A. decurrens* (23 ft. 6 ins.) is much better grown than *A. mollissima* (15 ft. 6 ins.) and *A. pycnantha* (15 ft.). The two *Callitris* look well and are both over 6 ft. *Prunus serotina* is a very quick-growing broadleaved species (14 ft. 6 ins.) and looks healthy. The *Ulmus* and *Fraxinus* spp. and *Chamaecyparis thyoides* are miserable and hardly survive.

288. *Comments on the* 1954 *plots.* (at 1 year old). The Eucalypts have done well in their first year, the best being *E. bridgesiana* (12 ft. 6 ins.), *E. regnans* (13 ft.) and *E. diversicolor* (11 ft. 6 ins.) *E. grandis* of Australian origin is 11 ft. 6 ins. and *E. saligna* of S. African origin is 10 ft. *Callitris calcarata* looks healthy at 3 ft. 6 ins. *P. pinea*, *P. hondurensis* and *P. massoniana* are all healthy but rather slow in starting. *Tristania conferta* (5 ft.) and *Broussonetia papyrifera* (5 ft. 6 ins.) look very healthy and have started well. *Podocarpus gracilior* looks very healthy at 3 ft., *Fraxinus pennsylvanica* var. *lanceolata* is very poor as also is *Robinia pseudo-acacia.* The bamboo, *Oxytenanthera abyssinica* has taken well and the new culms average 10 ft.

289. *Live hedges.* A start was made in 1954 with raising a series of demonstration live hedges for use in farm and forest work. The nine species planted have all done well. *Rosa multiflora* has been constantly browsed by buck and without protection this species obviously cannot be raised successfully here. Only the *Buddleia* has so far reached the 5 ft. height specified for a hedge and has had to be clipped

twice. The species are:—*Aberia caffra, Rosa multiflora, Duranta plumieri, Cupressus lusitanica, Euphorbia tirucalli, Dodonaea viscosa, Hakea saligna, Buddleia* sp., *Callitris rhomboidea.*

290. *Periodic height growth.* Measurements have been continued. The remarkably uniform and continuous growth from month to month which was observed with most species during the period November 1952 to December 1953 remained the main feature during 1954 and the first four months of 1955. No general correlation between seasonal climatic conditions and growth has been detected so far with well established trees of the species under observation.

291 Total height increment during 1954 with most of the species measured since 1952 was greater than in 1953 (with *Pinus patula* and *P. radiata* over twice as great) but there was little variation from month to month. The higher rate of growth in 1954 was probably in part due to the better rainfall than in 1953 (a very dry year) and in part due to the trees being older and better established. An exception was *Casuarina equisetifolia*, with which height increment in 1953 was greater than in 1954. No particular spurt of growth was apparent either during or after the very heavy April—May rains of 1954. In the case of *Cupressus lusitanica*, all 3 plots showed a check during July coincident with slight dieback of the tips of many leading shoots. Excessively wet soil conditions may have been the cause. Good growth was soon resumed. Neither *Pinus patula* nor *P. radiata*, which ceased growing during the the January—March dry season in 1953 (their first planting), showed any check during the corresponding periods of 1954 or 1955. Measurements of *Eucalyptus saligna* and *Casuarina equisetifolia* have now been stopped as the trees are too tall for accurate measurement, and measurements of some of the other species will shortly have to be discontinued for the same reason.

IV. ENUMERATIONS

292. Further work was done in the territories particularly in Uganda where a number of volume tables were also made by improved methods. Work in this subject by E.A.A.F.R.O. was purely advisory.

V. REGENERATION OF HARDWOODS

293. Further work was done in the territories ,chiefly in Uganda and Tanganyika, particularly in experimental work and the estimation of regeneration and advance growth. Large-scale district work on the poisoning of unwanted weed trees has been started in Uganda. Work in this subject by E.A.A.F.R.O. was advisory.

VI. SHORT-TERM TREE CROPPING

294. An experiment of 10 acres has been planted at Muguga in 1955 to test the relative fuel yields of local *Eucalyptus saligna* and *Eucalyptus grandis* and *Eucalyptus saligna* of Australian origin.

VII. YIELD TABLES FOR IMPORTANT SPECIES

295. A new Sample Plot in 10-year old *Eucalyptus saligna* in the E.A.A.F.R.O. Estate was laid out in 1953.

296. As a result of the Silviculture Specialist Committee meeting held in November 1954, work has started on the collection of height/age data so that the quality classes of Cypresses of the *C. lusitanica* group, and of *P. radiata* and *P. patula*, can be standardised on an East African basis. Work was also started on the collection of volume data for the preparation of yield tables for these three species.

VIII. MUGUGA (E.A.A.F.R.O.) ESTATE

297. Maintenance of the forest estate has continued. Work has included the thinning of neglected wattle plantations and new plantings of Eucalypts to provide fuel for the station.

THE DEVELOPMENT OF ANIMAL INDUSTRY RESEARCH

SURVEY OF PROGRESS

M. H. French

298. The Animal Industry Division, a joint research enterprise of E.A.A.F.R.O. and the E. A. Veterinary Research Organisation, has been settling to a programme of research and the development of the 400-acre farm at Muguga South. Limited financial resources have delayed progress in developing the farm and its stocking, and have led to an interim abandonment of certain of the research projects enumerated in the last report. It is hoped, however, to return to these shelved problems later. The recent arrival of Dr. Quarterman will enable a start to be made on the biochemistry of certain herbage carbohydrates and the changes which take place in these components during growth and maturation. It is hoped that these studies will be complementary to those on plant nitrogenous compounds being conducted by Dr. Duthie and that both will integrate with the digestibility and nutritive-value investigations of Dr. Rogerson.

299. In conformity with the inter-territorially agreed programme, the major activity of the Division has been to investigate the productivity of grassland and the means for assessing its yield and nutritive value. The variance between plot sizes employed, even in the temperate parts of the world where the soils have been cultivated for long periods, rendered imperative the need to examine this problem afresh under local climatic and soil conditions, especially since the land on which pastures are being grown have only been reclaimed from shrub-grassland, bush and forest within a comparatively few years. Quite apart from the greater variance in soil fertility, growth in the semi-arid regions is intense for a restricted period and the herbage is subjected to long intervals of dormancy by the harsh environment. It would be surprising if the local pasture species behaved in the same way as temperate species, in their vastly different natural habitat, and the indications are that the necessary plot size for the statistical study of such factors as yields, fertiliser effects and nutritive values will be different. In view of marked annual differences in time, and the intensity and distribution of rainfall, it would be unwise to rely on the results of one season's herbage growth. The studies conducted last year will be repeated in the current year.

300. Studies were made on the yields of Star, Rhodes and Kikuyu grasses, lucerne and oats from plots of 6 square yards and a total of 8,487 samples were cut, weighed, chaffed and dried for dry-matter contents. This is an achievement of which the members of the Division may be proud, especially when it is remembered that in the early months

of last year it was possible to dry grass samples at the rate of only sixteen in two days. With the help of the Maintenance Superintendent of E.A.A.F.R.O., large drying ovens were constructed and it is now possible to handle up to 600 samples a week during the peak period of the growing season. The dry-matter yields are being studied statistically by Mr. Robinson. It is hoped that ultimately a reliable plot size, for a given level of replication, will become known, so that all grassland workers in East Africa will be able to unify their experimental layouts and avoid the present ambiguities that arise from the adoption of different sized layouts based on overseas work.

301. Apart from the serious interference which the above dry-matter determinations caused to his other work, Dr. Rogerson carried out 35 digestibility trials with some 24 different feeding stuffs. It was hoped that these nutritive studies would have been applied to green grassland herbage, using an approved technique from Britain ; but the plots planted for this purpose were not in a suitable condition. In consequence, studies were made with dried fodders and a number of previously undetermined digestibility values were recorded. More important, however, from the point of view of determining the feeding values of the rapidly growing East African grasses in their short season of growth, the opportunity was taken of investigating the relationship existing between digestibility determinations carried out by a few sheep over a long period with comparable estimates for a number of animals for a short period. The results of this study are being applied during the current green-herbage season, in an attempt to evaluate Star, Rhodes and Kikuyu grasses.

302. As stated in last year's report, it was hoped to investigate the correlations between cut-herbage yields and the liveweight changes in grazing animals, in view of the many attempts to use the latter method for assessing the economic importance of the better species of local grasses. Many factors are involved in such comparative studies and, from the borrowed animals on the farm, it was hoped to secure data on the effects of age, size, breed and previous nutritional level of cattle on grazing responses and the effects of these in assessing the relative values of grass. Five months were spent in the preliminary studies, including training to weighing and pre-conditioning to various food intakes but, before the fields were ready for grazing, the animals had to be returned to their owners for various reasons. This matter is raised, not because of our lack of appreciation and gratefulness to the owners for the loan of the animals, but to focus attention on the impossibility of a research unit, such as this, depending on borrowed animals for its investigational

purposes. In spite of its considerable economical significance, the experiment could not be carried out last year and must be postponed until such time as the Division has absolute control over its experimental animals.

303. Instead of the above programme, one field only was grazed twice by a miscellaneous bunch of young animals ; and comparative evaluations of the herbage yield from the liveweight changes were made alongside the cage technique of Rothamsted and our own modification of the latter. As would be expected, the results merely emphasise the need for properly controlled, replicated layouts.

304. In an attempt to speed up the individual feeding trials with pigs, some 30 weaners were bought in because of the inadequate size of our own breeding herd for supplying the experimental needs. With these pigs came a virus pneumonia which spread to our own unit and interfered with progress. Altogether, 41 individual feeding trials have been conducted and it is hoped soon to be able to publish the results. Progeny carcase grading has led to the elimination of one of the original three sows purchased by the Division because of excessive fatty tissue on the shoulder and the consequent down-grading of her progeny by the factory.

305. Some progress has been made in improving the egg productions of birds in the poultry unit ; but there is need to expand the size of the unit. The original five breeds are being maintained, but rigid selection of the North Holland Blue unit has been necessitated by the selection of a meat strain rather than egg producers in one case and the uneconomic consequences of this segregation. Incubation continues to be a serious problem, not only because of an unusually high infertility rate but because of abnormally high losses in the developing embryos. The extent to which the low atmospheric humidity and oxygen contents contribute has not been worked out because of infertility complications, but, while low oxygen tension may be a contributing factor, experience with normal hatchings under hens suggests that it is of less importance than the maintenance of proper humidity relationships. The infertility problem is being investigated to see if various vitamins alone or in combination have a corrective effect when added to the standard rations.

ANIMAL NUTRITION

A. Rogerson

306. During the past sixteen months, thirty-five sheep digestibility trials have been carried out at the Metabolism Laboratory, involving

twenty-four different feeding stuffs. A wide range, including hays, straws, silages, green fodders and roots, locally produced concentrates, semi-concentrates and by-products have been studied and the actual feeding stuffs investigated are listed below :—

Hays	Meadow hays
	Cynodon hay
	Oat hays
Straws	Barley straw
	Maize straw
	Oat straw
Silages	Oat silage (untreated)
	,, ,, (molassed)
	,, ,, (lactic)
Green Fodders and roots	Indigofera subulata
	Forage oats
	Fodder beet (Pajberg Rex)
Concentrates,	Cottonseed cake
semi-concentrates and	Oats
by-products	Linseed cake
	Pollards
	Brewers' grains (dried)
	Cassava
	Pineapple residues (dried)
	Sunflower heads
	Sunflower seeds
	Coffee hullings
	Corn cobs

307. The digestibility trials with the hays and straws were straightforward, the only deviation from the accepted British method being the larger numbers of animals used. The daily figures from these trials were grouped to simulate trials of varying durations to determine what reduction of trial length could be effected by use of more animals. These experiments, besides yielding the nutritive values of the various fodders, have also enabled a technique to be developed which will be used this season for trials on freshly cut grasses, to meet the need for a technique capable of handling the rapidly growing wet-season herbage.

308. Satisfactory trials have also been completed on some locally produced supplementary feeds and by-products. These include digestibility experiments with coffee hulls, sunflower heads, linseed cake and cotton cake, the results of which have been or are in the process of being published in the *East African Agricultural Journal.* Trials on other local by-products, brewers' grains, pollards and pineapple residues have been successfully completed and the results will be published shortly.

309. In contrast, the digestibility trials on oat silages gave rise to some concern. It would seem possible, by a suitable variation of the hay/silage ratio, to alter considerably the calculated feeding value of the secondary ration (silage). This difficulty does not appear to have been encountered by workers in Britain, who give a definite feeding

value without stating at what particular level the silages were included. In digestibility trials, with hay plus concentrates, exaggerated figures for crude fibre digestibility have, on occasions, been obtained — particularly so in the case of oats (seed), where the addition of the concentrate would seem to have had the effect of improving the digestibility of the basal hay ration. Whether the variation in the digestibility of the silage can be so easily explained seems open to doubt. In view of the above results the interaction resulting from the feeding of a secondary feeding-stuff with an average-quality local fodder was thought to justify further intensive study, and a series of trials was conducted in which cassava flour was added, at various levels, to a basal ration composed of typical meadow hay. The results confirmed the generally accepted belief that the addition of a readily available carbohydrate causes a reduction in the digestibility of the crude fibre of the basal ration. The addition of cassava at a higher level caused a further decrease in the digestibility of the crude fibre and, at the same time, reduced the digestibility of the crude protein. A further addition of cassava, while causing no appreciable reduction in either the protein or fibre digestibility, had the effect of considerably reducing the digestibility of the nitrogen-free extractives.

310. Assuming the hay digestibility to be constant throughout the series of trials, the interaction of the primary and secondary components can best be illustrated by giving the calculated starch equivalent of cassava at the three levels of intake.

500g. hay + 100g. cassava	82.9 S.E.	0.90 D.C.P.
500g. hay + 200g. cassava	79.2 S.E.	Negative D.C.P.
500g. hay + 300g. cassava	75.8 S.E.	Negative D.C.P.

A further trial was carried out at the 300g. cassava intake level when 5g. urea was added daily. No effect on either the crude fibre or crude protein was noticed, but the digestibility of the nitrogen-free extractives was slightly increased and the starch equivalent rose to 77.3 (negative D.C.P).

311. A bomb calorimeter has now been secured ; but, to date, apart from the standardisation of the bomb, only a few preliminary determinations have been carried out. The above series of hay/cassava trials would seem to provide useful material on which to conduct further studies and these will be carried out as soon as practicable.

312. During this digestibility work, out of a possible 2,900 trial days in the period covered (six sheep is the largest number that can be dealt with at present) one thousand sheep days were actually spent on trial. This figure must at least be doubled to give the number of sheep days actually spent in the digestibility crates, because of pre-trial feeding,

interval between trials, etc. In addition to the digestibility work, the laboratory has assisted in the uniformity trials carried out by the Joint Division and, as already mentioned, over eight thousand dry matter determinations have been carried out in this period.

NITROGEN STUDIES ON HERBAGE

D. W. Duthie

313. An investigation has recently been started on the nitrogen fractions of herbage in relation to feeding value. The rapid growth of grass at the onset of the rainy season renders it difficult to carry out digestibility trials, with standardised techniques, on representative samples of very young grass. The results obtained by the accepted methods of chemical analysis do not give the complete picture of the nutritive value. Nevertheless the problem of the best utilization of young grass is of considerable importance in farming practice. It is well known that in East Africa the first flush of grass may not yield the liveweight increases and milk production that could be anticipated from results in temperate regions, and the object of this study is to find a chemical explanation of this. Samples of hay and dried green grass which were used by Dr. Rogerson in his digestibility trials will be studied for comparison, in order that some reference to actual feeding values can be made.

CARBOHYDRATE STUDIES ON HERBAGE

J. Quarterman

314. In the evaluation of the feeding values of herbage, conventions are used which are based on analyses of fodders grown in temperate climates. Irregularities have been observed in these values in the tropics, particularly in connection with the crude fibre content. Experiments are in progress to determine if there is any difference in the metabolism of tropically-grown grasses from those produced in temperate areas, particularly with reference to structural components.

315. Six species of grass (*Lolium italicum*, *Chloris gayana*, *Pennisetum purpureum*, *Digitaria scalarum*, *Cynodon dactylon*, *Pennisetum clandestinum*) and one leguminous species (*Indigophora* sp.) are being analysed at intervals from the beginning of growth, to study, in particular, the changes in lignin, cellulose and xylin components. The growth curves thus obtained can then be compared with similar data from temperate countries for the same or comparable species of grasses. It is planned to procure samples from other areas of East Africa for comparison with the results obtained at Muguga.

316. The few results so far available are tending to confirm the relatively high lignin content of at least one species of grass (Rhodes), even before the end of the rainy-season growth period. It is possible that one of the causes of the high lignin content may be the very dry conditions occurring at intervals during the growth period. Experiments are also being undertaken to examine the correlation of soil moisture and lignin formation.

POULTRY PRODUCTION

M. H. French and A. F. Dent

317. In the last annual report details were given of the first-year egg records of birds imported as day-old chicks from the United Kingdom. A number of these birds have now been recorded for a second year. Poultry producers are constantly concerned with the need to cull non-productive layers and to decide whether to renew their flocks annually or whether it is worth while to continue for a second laying season with good first-year birds. Arguments derived from overseas data, obtained under different climatic, nutritional and management conditions, could conceivably lead to important economic errors ; and, although the following information has been secured with units of only 10-16 second-year birds, they have an important bearing on commercial practice. The feeding and housing conditions were the same for all breeds and the ration used complied with modern ideas on digestible protein, starch equivalent and mineral requirements. Green food was fed *ad lib.* but without specific vitamin supplements. All birds were trap-nested in both years.

Average Egg Yields of Imported Birds

Breed	First Year's Egg Yield	Second Year's Egg Yield	Second Year's Yield as % of First Year Output
Brown Leghorns	159.1	116.1	73.0%
Cambars	209.9	121.4	57.9%
Legbars	183.2	98.2	53.6%
North Holland Blues	191.8	114.9	59.9%
Welsummers	153.1	75.1	49.1%

318. Quite obviously the commercial possibilities depend on food, housing, labour and management costs and there is considerable need to select within breeds for hens capable of profitable production over a number of years. This matter will be a feature of future work but, with the small numbers available, progress will be slow. The outstanding feature of the present data suggests that under Muguga conditions the decrease in egg production from the first to the second laying year is greater than recorded in temperate areas. This study will be continued with F_1 and subsequent generations to determine whether locally reared birds can be selected for more persistent production.

319. In the next table are given the average annual first-year egg outputs from F_1 birds reared locally, together with the recorded productions of their dams, hatched in England and flown out as day-old chicks.

Comparative Egg Yeilds of Imported and Locally Bred Birds

Breed	Average first-year egg yields	
	Imported Birds	F_1 Birds
Brown Leghorn	141.5	180.8
Cambar	176.5	183.3
Legbar	145.5	157.1
North Holland Blues	141.1	160.7
Welsummer	138.8	129.0

Whilst the increases for most breeds are satisfactory, the results with the Welsummers emphasise the failure to select, and use with this breed, males possessing an adequate egg potential to augment that of the females with which they were mated. The original breeding programme for these birds may also have been involved, in that no selection of future dams was made according to the age at which the pullet started to lay. In all other cases, the early layers were used as the dams of future generations. The North Holland breed is relatively new and was developed from widely different types and it is interesting to compare the results of progeny hatched from the pullets that firstc ame into lay

with comparably reared and managed progeny from the last group to begin laying. The pullets used in both pens were from the same incubator hatch ; but, whereas the first pen began laying at 20 weeks of age, the second pen was on the average 4 weeks later. Also a lighter type cockerel was used in the former pen and a more meaty sire in the second. These sire characters will undoubtedly have contributed to the pronounced differences between the first-year records of the two sets of progeny.

EGG YIELDS BY NORTH HOLLAND BREED

	Dam's average first-year egg yields	Progeny's average first-year egg yields
Pen 1	137.0	159.7
Pen 2	154.0	72.2

Naturally all birds in the second strain have been discarded and the figures are given merely to show how vastly different progeny records can be secured from the same strain of imported day-old chicks.

EXPERIMENTAL FARM

H. P. Ledger

320. Although much development such as the clearing of bush for forest, the erection of fences, etc., still awaits completion before all the available land is ready for use, the past year has been one of consolidation. At the same time there has been a change from straightforward land development to full-time experimentation.

321. During the initial development period, from 1951-54, a wide range of crops was cultivated. Many were grown in small plots but others were on a field scale, with the object of clearing the land of weeds and providing suitable conditions for subsequent experimental work. Valuable data on the potential of the farm have been secured ; and these confirm the opinions expressed at the beginning of the operations by established farmers in the neighbourhood that this is not an economically safe arable-farming district. In judging the potential of the farm it must be remembered that, in addition to the normal hazards of varying rainfall, local pests, etc. connected with commercial farming operations, the farm is subject to the restrictions implicit in the efficient running of an experimental station. An example of the latter is that, whereas one could

reasonably expect to overcome some of the hazards of crop production by the judicious use of fertilisers, this is not permissible on an experimental farm because it would render the treated areas unsuitable for many years for any study of soil nutrients.

322. Before summarising the farm results, it is desirable to refer briefly to certain topographical and climatic limitations. The altitude varies from 6,500 ft. to 6.900 ft. and the farm lies less than two miles to the east of the Rift Valley. This latter factor markedly affects both the annual rainfall and its reliability, which are materially less than in similar country a few miles to the west of the farm. In fact, the Muguga climate is neither truly high-altitude nor typically sub-tropical but, in spite of the much advertised criticism of its atypicality, it has features which could be advantageously employed in a study of the climatic adaptability of livestock to the higher altitude areas of East Africa.

RAINFALL — PROBABILITY TABLE

Station	Mean Rainfall	Probability of obtaining a given rainfall in any one year		
		Less than 30 ins.	Less than 25 ins.	Less than 20 ins.
Kikuyu Railway Station	31.5 ins.	40–45%	25%	10–12%
Muguga Forest Station	35.6 ins.	32%	18–20%	10%
Limuru–Tigoni	40.1 ins.	17%	7.5%	2–3%

323. The above table has been constructed by Mr. Glover; but, owing to the lack of records over a sufficient number of years, it is not possible to include rainfall probabilities for the farm. It would appear, from the available records, that its rainfall approximates that of Kikuyu Railway station rather than that of the Muguga Forest station.

324. *Fodder Crops.* From the records of the past three years there is little doubt that many fodder crops can be grown in the long rains and can be relied on to yield well. Of these, oats or maize on their own, or preferably with a vetch, pea or other suitable legume, can produce at least a ton of *dry matter* per acre. Both marrowstem and thousand-headed kales, provided they are drilled early, are invaluable, not only for the bulk of fodder per acre that they produce but also for their ability to provide a green fodder throughout the dry season. During the very

dry year of 1953, when only 22.5 inches of rain were recorded, and also when the short rains failed in 1954, kale was the only supply of green fodder available. Fodder-beets have been tried on a small scale but the results were extremely variable. It would appear that unless the plant receives sufficient rain during its root development, it is unable to perform this function later. If, however, this requirement is met, good yields can be obtained and, once formed, the roots will remain sound even when left for some months in the ground. Provided they are not clamped they can be satisfactorily stored ; but if they are clamped, as is the practice in temperate countries, they will soon rot.

325. *Cereals.* Several varieties of maize have been tried but none has exceeded the six bags per acre, yielded during the wet year of 1951. Even this yield was deceptive as the grain was of inferior quality. In this area the difficulty is to get seed formation at the proper time. With the more usual varieties, the rate of maturation is too slow and the grain is barely ready for harvesting by the onset of the short rains. If the short rains are good, harvesting becomes extremely difficult ; while, if they are poor, the plants are unable to obtain sufficient moisture to produce satisfactory yields. It was hoped that early-maturing varieties might help to overcome this problem but this aim has not yet been achieved with the varieties so far tested. This result was disappointing but may be associated with the dry, warm conditions, which follow the long rains, interfering with the ability of the plants to secure their rather large water requirements at the cobbing stage.

326. A further handicap to the successful harvesting of maize is that of theft. The farm is bounded by a native reserve and is consequently exposed to large-scale pilferings. While the clearing of bush and existing emergency regulations reduced such thefts, it cannot be forgotten that from 15 acres, planted out of sight of the Farm House in 1952 and in spite of the employment of night guards, a conservative estimate showed that two-thirds of the cobs were stolen.

327. Of the smaller grain cereals, there is no doubt that if a cheap and satisfactory method could be devised to exterminate or control the vast flocks of small birds which annually ravage the crop, barley would produce good yields. Unfortunately, no small grain cereals are grown on a field scale for a radius of many miles, with the result that the crops on our farm are ravaged by thousands of birds, against which all normal bird-scaring devices seem to be useless. An indication of the possibilities of barley is that in the dry 1952 season 7½ bags per acre were secured from a moderately fertile piece of land and from which, unaccountably, the birds only took about a quarter. Admittedly, greater yields and

enhanced bushel weights could be secured with the judicious use of fertilisers.

328. Oats have proved useful for hay and silage purposes but, if left for grain, have failed to attain a reasonable bushel weight. No doubt fertilisers, if permissible, would assist, but the bird problem would remain. Kavirondo sorghum left for seed provided a reasonable crop, which the birds harvested almost completely. Bulrush millet flowered but failed to produce seed. Probably this was an altitude effect on a crop normally more suited to a warmer climate.

329. *Legumes.* Canadian Wonder beans grown in the short rains of 1951, on recently broken land which was far from clean, produced a promising crop of 4½ bags per acre. Since then, however, yields have been most disappointing. This is partly due to the short rains of 1953 and 1954 having failed, while the beans grown during the long rains in these years suffered increasingly from insect damage. This damage has become more serious with each succeeding crop, reducing the yield to 2½ bags per acre in 1953 and to less than one bag per acre in 1954. *Fiwi* beans grown on a small acreage this year appeared to be a promising crop. They are hardy, drought-resistant and to date have not been attacked by any pest. It is, however, a late-maturing crop which, planted during the long rains in April, can be harvested from November to January.

330. *Long-Term Experiments.* Long-term experiments to study the efficiency of existing techniques in evaluating pastures under East African conditions have been started. These are described in an earlier part of this report. Further plots have been established to obtain data on the productivity of Star grass under different systems of management, i.e. combinations of grazing, hay-making, silage-making and leaving for standing hay. The herbage productions per acre have been recorded but, as with the above uniformity trials, the results from a single season require supplementation before they can be published. Consequently, the experimental programme will be repeated to determine the seasonal variations to be expected in herbage yields. The existing data are being statistically analysed by Mr. Robinson for publication.

331. The effect of different rates of defoliation on the annual dry-matter yield of Star grass has been studied and preliminary tests made on the technique of conducting grazing trials.

332. In conjunction with Mr. Dougall, Pasture Research Chemist of the Kenya Agricultural Department, work has continued for the second year, studying the effects of fertilisers on the establishment and maintenance of a Star grass ley. The management of stock and the

arable cropping procedures connected with the long-term investigations into problems being studied by the Soil Physicist have continued.

333. *Sheep.* There was a marked improvement in the health of the flock and all animals born were hardier than those bought during 1952-53. All but one of the Persian Blackhead sheep, purchased from Tanganyika, and both pure-bred Dorset Horn lambs born on the farm have died. In no case was death attributed to any specific disease but may possibly have been related to the animals' inability to adapt themselves to the local environment. None of the imported Dorset Horn sheep has lost condition since their arrival in 1952 and, at the time of writing, the first crop of half-bred Dorset Horn X Masai lambs are being born.

334. *Pigs.* In addition to food-conversion and carcase-quality studies, conducted on the progeny of the three Large White sows bought from Mpwapwa, similar studies were undertaken at the request of the Kenya Pig Industry Board on groups of weaners bought from local producers. Unfortunately this work could not be adequately completed owing to the inability to purchase further weaners of the standard and uniformity necessary for this work. Lack of funds has also interfered with the purchase of sufficient in-pig sows to make the unit economic. Consequently, in order to obtain sows to provide the requisite numbers of weaners for feeding trials, females must be kept back from the factory. The evaluation of the efficiency of any ration fed or strain of pig bred during the next two years will accordingly be influenced by this removal of the better females.

AGRICULTURAL STATISTICS

P. Robinson

335. A large proportion of the work carried out during the period under review was concerned with entomological problems. A visit was made to Asmara in Eritrea to discuss with officers of Desert Locust Control statistical methods applicable to the study of the distribution of the insects. (Here " distribution " is used in its statistical sense, and does not mean geographical distribution). It had been suggested that mathematical methods could be used to determine the relative importance of (i) an inherent gregarious habit and (ii) a natural set of circumstances (such as attraction to shade, etc.) in the aggregation of the insects. Statistical methods alone, however, can merely demonstrate that there is some form of association, but cannot determine its cause.

336. A short visit was also made to the entomological laboratory at Lyamungu, in Tanganyika, to discuss experimental designs for testing various methods of control of the White Coffee Borer. The borer is the larval stage of a flying insect. With a mobile source of infection it is necessary to overcome as much as possible movement from plot to plot. Available data were examined and an extensive series of experiments was suggested.

337. A similar insect pest is also of great economic importance in forestry. The larval stages of Oemida bore into trees and reduce the value of timber considerably. It is impossible to determine whether a tree is infested until it is felled, and obviously it is not possible to fell all trees in a plantation to determine the rate of infestation. Sampling methods and statistical interpretation were suggested, but so far these methods have not been tested.

338. Finally, experiments testing various methods of control of insect pests in stored grain were analysed for the Agricultural Department of Kenya. Assistance has also been given in the design and analysis of other experiments and interpretation of results for the Department of Agriculture and Forestry in Kenya and Tanganyika, and also to other organisations in the territories.

339. A central "bureau" has been set up for the collection of results from fertiliser experiments on a variety of crops in East Africa. It is hoped eventually that these results will be collated and examined with a view to determining the effect of rainfall, altitude, soil type etc. on responses. This is obviously a long-term programme, and results of such an investigation will not be available for some time to come. In the meantime, it is hoped the "bureau" will be used by research workers in East Africa for obtaining initial information on the problems they wish to investigate.

340. Two co-operative experiments, testing the effect of altitude and different methods of chemical analysis on the determination of various feeding-stuff constituents, were examined. The results of phosphate determinations, when workers using different methods in the first experiment, were not consistent; and more comprehensive series of tests were made in the second, testing five methods of chemical analysis. Copper and calcium determinations were consistent, but the variation was rather high for the former. Different laboratories gave significantly different values for both crude fibre and crude protein in the various materials analysed.

341. A certain amount of confusion appears in the literature concerning the accuracy of determining liveweights of animals in experimentation. It would appear, in general, that weighing on one day, instead of the general practice of weighing on several consecutive days, is all that is necessary when comparing different groups of animals. If accurate measurements of liveweight increase of a single animal, or a single group of animals, is required, however, then weighing on several days will improve the accuracy.

342. A series of uniformity trials carried out by the Animal Industry Division on various herbage crops was examined. The general conclusion is that plot sizes should be much larger than is at present used in East Africa, particularly with Kikuyu grass. Other grasses tested were Star and Rhodes and, in addition, natural regeneration. Oats and lucerne were also examined.

MISCELLANEOUS SCIENTIFIC SERVICES

THE JOINT E.A.A.F.R.O./E.A.V.R.O. LIBRARY.

L. D. Verdcourt

343. During the 18-month period under review much of the Librarian's time has been taken up by the amalgamation of the East African Veterinary Research Organisation Library with that of E.A.A.F.R.O. This involved the binding and checking of the many periodicals, typing of book cards for each volume, labelling and shelving in the Library. This main work is now near completion, and the next year will be spent in maintaining and steadily building up the collection to a worthwhile working veterinary library. Routine work in the library again took up a good deal of the working hours, but several extra tasks were carried out, such as the cataloguing and filing of the map collection and the meteorological publications. Many valuable exchanges of material were made through the British National Book Centre Scheme in which the Library participates.

344. In May 1955 the new bookbinding workshop was almost completed and the bookbinding staff and equipment transferred with the minimum amount of delay to avoid any break in their work. The much needed stack room, which is essential to any library, adjoins the bookbinding room under one roof and should prove most useful when finally completed. The old bookbinding room is thus freed for a library work room, where typing and book preparation is now done.

345. More books were issued on loan during 1954 and the first half of 1955 than previously, and many more requests were made by scientific officers for publications not in the library. Through the help of the Council for Scientific and Industrial Research in South Africa many of these requests were satisfied by photographic copies. Altogether 65 volumes were obtained on loan from places as far apart as Sierra Leone and Edinburgh, as well as from 23 different libraries in South Africa.

346. The library staff remained unchanged during the period 1954-1955, but two learners joined the bookbinding unit and the total output was 1,831 books and 202 cardboard boxes, increasing the output per man to nearly 18 volumes per month. The equipment was overhauled in the E.A.A.F.R.O. workshops and the guillotine was re-mounted on a secure metal stand. The urgent requirement for book presses, which are very expensive, is being met by the Maintenance Superintendent who undertook to make them in the workshops.

347. The Librarian proceeded on overseas leave in May 1955 and Mrs. S. Evans took over the routine work for the six-month period.

EAST AFRICAN AGRICULTURAL JOURNAL

D. W. Duthie

348. During the eighteen months under review the size of the Journal has increased somewhat, owing to the large number of suitable articles which have been received: the average size of a number during the period is 70 pages. Five articles on subjects connected with fisheries have broadened the scope of the Journal, which now covers veterinary science, forestry, fisheries, and a wide range of agricultural subjects including animal industry. In addition, a lengthy report on a conference on the medical, agricultural, and veterinary aspects of food production in East Africa was published in the July 1954 number: this included the opening addresses, summaries of papers read, and a record of the discussions and summing up.

349. It has, in fact, been a very satisfactory period from the editorial point of view, but there has been a drop in the number of subscribers from 1275 to 1150. Obviously many farmers find the articles too technical for their taste; but the Journal is primarily a record of investigations which have been carried out in East Africa, and as such it prevents much valuable experience being buried in Department files. It is of the greatest importance that present-day technical officers should know what has already been done in East Africa on any particular subject, and now that the Journal has been running for 20 years a long record of information is available. This has become increasingly valuable with the expanding development of natural resources; and the small subsidy required from the three territorial Governments is more than repaid by the saving of time in searching for information on past work.

PLANT QUARANTINE STATION

F. M. L. Sheffield and G. A. Quinion

350. The East African Plant Quarantine Station is on a 5-acre plot in Muguga Forest and consists of a stone building containing an office, a laboratory and sterilising and potting rooms. There are eight metal-frame glasshouses, each divided into two independent chambers by a central partition and having a door at each end. The units measure 20′ × 6′, and half are 7′ 6″ high at the ridge and half 11′ 6″ high. The erection was complete and the water was laid on when the Station opened on 1st January, 1954. The electricity, needed for the thermostatically controlled heating and for the injection fans in the glasshouses, as well as for general laboratory purposes, was installed during 1954. African

quarters were built on the plot but have had to be closed during the Emergency. Two further glass-houses of the taller type have been ordered from the makers in England and will be erected as soon as they arrive.

Importations

351. With one exception (sugar cane), plants are quarantined only at the request of one of the Departments of Agriculture. As the aim is to introduce as many new varieties as possible, very few plants of each are accepted. A consignment usually contains several varieties and, as each consignment is grown separately, the total number is that which can be comfortably accommodated, together with test plants when necessary, in a single chamber.

352. *Sugar Cane.* New varieties of cane were a pressing need and, in the absence of requests for other economic plants, all the taller houses are at present devoted to them. Cane is imported by the Quarantine Station, the varieties chosen being those suggested by the Departments or by experienced growers familiar with conditions prevailing in the Territories. Two setts of each variety arrive by air, and in only one case, when they were considerably delayed in transit, has there been any failure of growth. Cane is retained for at least one year in the glasshouse and is frequently inspected for any signs of disease. As it is impossible to diagnose Ratoon stunting in the glasshouse, all cane will receive heat-therapy against this disease before general release. This treatment should be given immediately before planting and the Uganda Department of Agriculture has agreed to accept all cane released from Muguga, to heat-treat and to plant it out at Kawanda, where all the cane in the collection has been so treated. There it will multiply and, as soon as setts become available, they will be distributed to the other Territories.

353. Following is a list of varieties received into E.A.P.Q.S. during 1954. (The initial letter refers to the place of origin of the variety:— B, Barbados; Co, Coimbatore, India; H, Honolulu, Hawaii; M, Mauritius; NCo, seedling raised in Natal from seed from Coimbatore; POJ Proefstation Oost Java; PR, Puerto Rico.)

Supplied by The Sugar Cane Research Station, Mount Edgecombe, Natal.

B	4098	M	112/34
B	37172	M	165/38
Co	396	M	423/41
Co	475	NCo	292
Co	513	NCo	293
Co	602	POJ	3016
Co	617	PR	905

Supplied by The Imperial College of Tropical Agriculture, Trinidad. B.W.I.

H	32/8560	Pepe Cuca
H	38/2915	
H	38/443	PR 1000
H	39/3633	
H	39/5803	*Trojan
H	39/7028	
H	44/3098	

(*The two plants were very stunted after 10 months, the longest stem, consisting of 20 nodes, being only 14" long. They were destroyed. Subsequent enquiry in Australia, where the variety originated showed it to be quite unsuitable to East African conditions, as it needs a long day and a well watered alluvial soil.)

354. Two other varieties have also passed through quarantine. The setts, obtained from East African sources in response to requests from abroad, were not above suspicion and, as space was then available, they were grown in quarantine before dispatch.

355. *Ornamentals.* We expect to receive such plants as dahlia, chrysanthemum, begonia and arum lily. The lower houses will usually be used for these and for the production of any necessary test plants. The importation of possible symptomless carriers of Spotted-wilt disease has hitherto beeen prohibited, but small importations are now permitted through quarantine. The first commercial importations were slow in arriving and the opportunity was taken to import some of these species for experimental purposes. In a single situation, it is impossible to provide ideal growing conditions for a wide variety of species, but, if disease symptoms are to be recognisable, the best possible must be provided. At the stage of development at which they are received, plants may need a greater length of day than occurs in the Tropics. Alternatively, if they leave Europe in winter, they will be received here in very hot weather. Outdoor varieties may not grow well under glass house conditions. As the plants may carry disease and show no symptoms, testing methods had to be designed and allowance made for the difficulty often experienced in getting a positive reaction from sap extracted, for example, from an infected chysanthemum.

356. The first importation comprised six varieties of chrysanthemum. Each plant of this species will be tested six times at monthly intervals by mechanical inoculation to petunia plants, the juice being extracted into 0.5% solution of sodium sulphite and celite being used as an inoculation aid. Normally, if one plant of a variety is infected, all plants of that variety will be destroyed; and they must give six negative reactions before release. By the second test, five of the varieties in this consignment were shown to be infected with a virus, probably that of tomato

Aspermy. As it was an experimental importation, the plants were retained for further testing and, as expected, the results were very inconsistent. The fifth test showed all to be infected, but the last variety may have become so in the glasshouses; this would not normally occur, as plants would be destroyed as soon as they had given one positive reaction.

357. An experimental consignment of dahlia tubers arrived in a very shrivelled condition and germination was poor. This species will be given similar tests to the chrysanthemums but will be released after giving two negative reactions. Those that germinated have so far given one negative. Begonias and arum lilies will be tested as the dahlias. An experimental consignment of the former is not yet sufficiently mature to be tested.

358. One commercial importation of chrysathemums is now undergoing tests for the presence of virus disease. Both importations of chrysathemums were infested with aphids on arrival and these were destroyed with nicotine sulphate. The glasshouses are kept free of insect pests by regular spraying or fumigation.

ATTACHED C.D. & W. SCHEMES

ECOLOGICAL TRAINING SCHEME

C. G. Trapnell

359. The Ecological Training Scheme has been directed towards applied land-use survey, based on the combined use of vegetation and soil reconnaissance. The Scheme came into being at the end of 1950; but training work was not begun until the writer's return from overseas leave in 1952. During the three years 1952—1955 seven officers have undergone training for work in Uganda (two), in Kenya, Northern Rhodesia, Arabia and in North Borneo. Training work has, as far as possible, been combined with surveys of areas of direct interest to Territorial Departments, the larger working fields having been in the West Uganda Rail Extension Zone, in the Northern Province of Nyasaland and in the Machakos—Kitui and South Turkana regions of Kenya. The Training Scheme will terminate at the end of 1955; but a considerable accumulation of data bearing on the wider aspects of soil and vegetation interpretation in various regions remains to be prepared for publication.

360. Field work during the period under review was affected by the very diverse destinations of the officers concerned. At the beginning of 1954 personnel comprised Mr. W. D. Clayton, Colonial Research Student for the post of Ecologist, Nigeria, and Mr. C. F. Hemming of the Desert Locust Survey. Work with these two officers was combined on the basis of a previous request from Nyasaland, with collaboration with Mr. G. Jackson, Ecologist in that Territory. Mr. Hemming rejoined his Department in September and Mr. Clayton left to take up his appointment in Nigeria in October. Mr. D. I. Nicholson, appointed Ecologist, North Borneo, after service with the Forestry and Timber Bureau, Canberra, arrived on Mr. Clayton's departure; and Mr. J. G. Wilson, Agricultural Officer, Karamoja, joined the scheme in February, 1955, at the request of the Director of Agriculture, Uganda. Mr. J. R. Peberdy of the Kenya Agricultural Department was also associated with work under the Scheme for short periods in March and April, 1955.

361. Vegetation reconnaissance to determine the climatic zones of the denuded Machakos hill region had been begun in the last months of 1953, together with air-photograph interpretation of certain soil types. Field work was continued in January, 1954, and air-photograph interpretation of the vegetation of the northern 800 square miles of the region was then carried out by Messrs. Clayton and Hemming. Working vegetation maps of this area were prepared at 1/50,000 and subsequently reduced to 1/250,000. Plotting of the Kiteta soils (*vide* 1953 report) and of the soil complex of the Athi Plains margin was also continued, and a separate 1/50,000 map of the former was drawn by Mr. Clayton.

A commentary on the ten main vegetation zones of the region and their climatic and soil conditions was subsequently prepared for the Agricultural Department. The vegetation zones indicate a complex pattern of orographic variation of rainfall in which each valley is liable to differ from the next. Their climatic implications are of considerable practical interest.

362. In the latter part of March work was begun on an extensive reconnaissance of South Turkana, one of the main laying-grounds of the Desert Locust. The purpose of this survey was to develop a classification of a desert land-surface that would be applicable to investigations of vegetation and environmental factors in locust-breeding areas—desert vegetation patterns being considered likely to be largely influenced by edaphic conditions. The initial work was carried out by Land Rover traverses from Lodwar, Lokichar and Lorogumu, beginning in the last part of the most arid period and continuing after the onset of the brief rainfall. The dual control of arid wind erosion and sudden "flash floods", which characterises this region, was readily observable in the period and initial classification of soil and land-surface types was obtained. Traverse data were subsequently plotted by Mr. Hemming in conjunction with an examination of available air cover, and a working topographic map was also prepared by him from the air photographs with a view to further field work.In June he returned to the area for a longer period of survey, in which he extended soil reconnaissance as far south as Kaputir and Kangetet, and carried out a fuller study of the vegetation of the region. This included the ephemeral phase, which had not yet appeared during the first reconnaissance. He subsequently drafted a full account of the field soil classification arrived at in this region, together with a small-scale schematic map covering some 6,000 square miles. It is hoped to publish this account shortly.

363. During June and July, while Mr. Hemming's second survey was in progress, Mr. Clayton and the writer were on tour with Mr. G. Jackson in Nyasaland. This tour was undertaken in order to make observations on vegetation, soil and land use under the wide range of climatic conditions found in Nyasaland, and to advise on the procedure to be adopted for Mr. Jackson's ecological survey of the Territory. The Mzimba region had been examined during the previous year's visit. Observations on the present tour were made more particularly in the Karonga, Nkata Bay, Lilongwe, Dedza and Cholo-Chiromo areas, and a period was spent in Fort Johnston in collaboration with Mr. Jackson on his initial survey of that District. In the course of these journeys relationships between Nyasaland vegetation and soil types and those

of neighbouring territories were discussed in the field and observations, begun in the previous year, on the structural differentiation of Nyasaland red earths were considerably extended. Proposals for ecological survey, comprising a series of "special area" land-use surveys of selected regions, together with a territorial map of climatically significant vegetation types, were subsequently submitted to the Director of Agriculture.

364. In August I attended the C.C.T.A. Inter-African Soils Conference at Leopoldville, returning via Entebbe. Arrangements were made here for Mr. Clayton to carry out a vegetation and soils reconnaissance of the Moroto sector of Karamoja District: and he was engaged on this work over the latter part of August and first half of September. His report, including proposals bearing on future land investigations in this area, was subsequently transmitted to the Forestry and Agricultural Departments.

365. In November, following Mr. Nicholson's arrival in the previous month, a preliminary tour was made with him to examine forest areas in the Eastern and Western Usambaras and in the Kwale area south of Mombasa. Air cover was subsequently obtained for the Eastern Usambaras, and in January 1955 Mr. Nicholson returned there for a fuller examination of the Amani forest and plantations. Preliminary work was also done for a projected survey in the Kwale area, which, however, it proved necessary to defer till later in the year.

366. Upon Mr. Wilson's arrival in February further vegetation traverses were carried out in Machakos, south of the area previously mapped, in company with Mr. J. R. Peberdy. This was followed, at the end of March, by soil reconnaissance traverses over east Machakos and west Kitui Districts, a region which lends itself particularly to soil interpretation through air photographs. A characteristic pattern of extinct termitaria indicates the Kiteta soils in this area. Plotting of traverse data and work on the interpretation of the photographs was carried out by Mr. Wilson in April and May; and Mr. Peberdy at the same time visited Muguga to carry out air-photograph interpretation and mapping of the data obtained in the preceding field work in Machakos. Mr. Wilson returned to Kitui in the latter part of May for supplementary field work and soil-profile sampling, and a map of the principal soil types over an area of 300 square miles was then put in hand. This area includes the country to be watered by the Yatta furrow. Following completion of this work Mr. Wilson will be continuing with vegetation traverses in east Kitui District, and thereafter will be studying dry lands-utilisation questions in this region and northern Tanganyika.

367. In the meantime, arrangements had been made for Mr. Nicholson to carry out work in forest ecology in South Mengo District, Uganda, under Mr. H. C. Dawkins, Ecologist in the Forestry Department, Entebbe. Reports on the South Mengo forests, together with air cover, were forwarded in advance by Mr. Dawkins, and after preliminary work on these Mr. Nicholson left for Uganda, meeting Mr. Dawkins at Jinja for an initial examination of Mabira Forest. He then undertook, under Mr. Dawkins's direction, a detailed study of the ecology of *Lovoa* vegetation in Mpanga Forest. His subsequent programme is intended to include a visit to the INEAC Research Centre at Yangambi on questions of cartography and utilisation of forest land, to be followed by field work in the Kwale sector of the Kenya coast region.

TERMITE RESEARCH UNIT

W. Wilkinson and R. M. C. Williams

368. Messrs. Wilkinson and Williams were stationed at Muguga until March 1955, when Mr. Williams moved temporarily to the Agricultural Research Station at Kawanda, Uganda. Mr. Sands left Muguga in March 1954 on home leave, and has since been working on East African termites at headquarters in London.

369. *Systematics*. During the year 1954, 37 tubes of termites were determined in East Africa. Of these by far the greater proportion were *Cryptotermes dudleyi*, from Mombasa and Dar-es-Salaam. As far as the pressure of other work would allow, the two officers at Muguga continued their taxonomic revision of the Kalotermitidae and Termitinae. It is expected that these will be completed in 1956, and written up in conjunction with biological, ecological and experimental data obtained.

370 *Field Work*. Field work consisted mainly of tours designed to continue the work of plotting the distribution of East African termites, and obtaining material for taxonomic work. Particular importance is given to explaining distributions on an ecological basis, and as our records increase some success in this field is being achieved.

371. Mr. Williams is concentrating on a study of the *Cubitermes* mound complex, including an investigation, in conjunction with Dr. P. Hesse, of changes in the constitution of the soil caused by these termites. He has made several visits to the Highlands west of the Rift in pursuance of this project in the mountain grasslands, and has now moved to Kawanda where material is more easily accessible.

372. Mr. Wilkinson, whilst continuing his general survey of the Kalotermitidae, has been particularly concerned with the status of the

economically important *Cryptotermes dudleyi*. The recognition of this species, previously known in East Africa from one record, and the spread of ill-informed publicity concerning damage by termites in Mombasa and Dar-es-Salaam, made it desirable to investigate the situation. The species is present in all coastal settlements visited, except Mtwara, is well established, and responsible for considerable damage. It has not yet been found up-country, except in very recently arrived furniture. Preliminary reports on Zanzibar and the Coast have been provided.

373. The two major tours have been to the coastal strip of Kenya and Tanganyika (July — August 1954 : 7 weeks) and Uganda (February—March 1955 : 5 weeks).

374. *Biology*. Work by Mr. Sands on the feeding habits of *Odontotermes*, explained in previous reports, was completed, and is being written up for publication. Experimental biological work on the Kalotermitidae was extended. A large thermostatically controlled constant temperature box, with variable humidity chambers, has been built for this work. Several species are being tested for survival potential under varying conditions of temperature and humidity, with and without food. It is hoped that the results (although in the time available these will only be indicative and not conclusive) will help to explain the distribution of the species. Various methods of maintaining laboratory cultures for observation were tried. As an alternative to wood chips a mixture of pulverised wood and 2% agar was tested with some success. Attempts to start colonies from pairs of alates have so far failed, though mating and egg production has been achieved.

375. Observations on *Cubitermes* and related genera were begun, including their behaviour towards each other and towards ants, and on their interspecific relations in mounds of mixed populations. *Cubitermes* workers and soldiers have been used for the testing of techniques to be used in future experiments, particularly with regard to the maintenance of small numbers in small glass plates and to tests of various dyes and pigments to be used in experiments on feeding. Various kinds of observation nests were made, those of plaster of Paris, cork and linoleum not being satisfactory. A fairly simple pattern of glass nest containing earth has been found the most successful. In these cultures a colony can be kept in a healthy condition for many months, though the queen survives for only a few weeks. The keeping of dealate Cubitermes pairs has not been successful, as the few eggs produced have eventually disappeared.

376. *Economic*. Two 'graveyard' experiments were set up at Muguga :—

(a) To test the resistance to local termites of Plastic sheeting used in underground cables. Slabs of Podocarpus wood were wrapped in the material and half buried with unwrapped slabs as a control. The sheeting was found to be ineffective in protecting the wood against the attack of *Odontotermes badius*.

(b) In conjunction with the Kenya Forest Entomologist, at the request of the P.W.D., slabs of Grevillea and Podocarpus treated with an unknown preservative by three different methods were buried at random. Attack has not proceeded far enough to be able to compare the methods.

377. Identifications and advice continued to be given when required. Most of this concerned *Cryptotermes*, but subterranean and harvester termites were also represented.

RESEARCH BY OFFICERS OF THE TANGANYIKA AGRICULTURAL CORPORATION (FORMERLY O.F.C.)

ROSETTE DISEASE OF GROUNDNUTS

A. C. Evans

378. The promise shown by the variety Mwitunde for controlling rosette disease has been fulfilled for two seasons. In 1954 only occasional rosetted plants were seen and in 1955 the crop was free from the disease except for one small area ; but even here the incidence would not be high enough to cause an appreciable reduction in yield. The average yield for the variety on the production farms in 1954 was 1000 lbs. per acre and proved highly economic.

379. It has now been shown that Mwitunde has some tolerance to the usually crippling effects of the disease. Individual plants of Mwitunde and Kanyoma, another long-season variety, were infested with infective aphids 38 and 45 days after planting. At harvest striking differences in yield were shown between the varieties at both dates of infestation.

YEILDS OF ROSETTED PLANTS AT TWO TIMES OF INFECTION, IN GRAMMES OF KERNELS PER PLANT.

Variety	Age of plants at infestation.	
	38 days	45 days
Mwitunde	15.6	53.4
Kanyoma.....	4.1	28.2

Significant differences at P = 0.01 —

38 days 7.8

45 days 23.4

The differences between varieties were highly significant at both times of infection. Healthy plants of both varieties averaged 66g. of kernels at harvest.

380. A comparative study of the growth of healthy and rosetted plants of Mwitunde and Kanyoma provided interesting results. Plants were infected 40 days after planting. Mwitunde showed the first symptoms of disease 11 days later and Kanyoma 15 days later. Both varieties began producing gynophores at the same time. Results are presented for a harvest at 89 days after planting. This is very early, but baboons had begun to pull plants and the experiment would probably have been completely ruined in a short period.

COMPARISONS OF HEALTHY AND ROSETTED PLANTS OF MWITUNDE AND KANYOMA AT 89 DAYS AFTER PLANTING

Character recorded	Condition of plants	Variety		Significant differences
		Mwitunde	Kanyoma	
Mean fresh weight per plant at harvesting	Healthy	113	136	P. at 0.05 = 11
	Rosetted	85	72	P. at 0.01 = 15
Mean number of gynophores per plant at date when symptoms first showed	Healthy	6.7	7.5	P. at 0.05=1.92
	Rosetted	7.3	6.0	P. at 0.01=2.57
Mean number of full sized pods at harvest	Healthy	14.9	14.0	P at 0.05=3.7
	Rosetted	8.1	1.9	P at 0.01=5.0
Mean weight of kernels per plant at harvesting	Healthy	12.7	14.6	P at 0.05=1.7
	Rosetted	6.8	1.0	P at 0.01=2.4

381. The fresh weight of plants at harvest was appreciably reduced by the disease, Kanyoma suffering a relatively greater reduction that Mwitunde. The number of gynophores per plant when symptoms first showed was similar for both varieties whether diseased or not. The number of full-sized pods and weight of kernels per plant at harvest were reduced by disease, particularly in the case of Kanyoma. The relatively lower weight of rosetted Kanyoma plants and their low kernel production suggests that the virus reduces assimilation much more severely in this variety than in Mwitunde.

LEAF-SPOT DISEASES OF GROUNDNUTS

J. S. Hemingway

382. Observations were continued on the character of the resistance to *Cercospora personata* and *C. arachidicola* possessed by several varieties of groundnuts. Resistance is expressed by the establishment of fewer lesions, with a slower rate of growth and smaller maximum size. (The variety " Natal Common " is used as a standard of susceptibility).

Comparative Resistance of Three Varieties to *C. personata*

Variety	Lesions per 10 plants under uniform infection	Lesions per stem	Lesions per petiole
Kanyoma	11.7	2.3	1.4
Mwitunde	20.8	2.5	1.7
Natal Common	24.6	16.0	4.6

Variety	Areas of lesions (X 1/1000 sq. ins.)	
	Average area	Increase per day
Kanyoma	4.5	0.6
Mwitunde	6.9	1.0
Natal Common	10.6	2.5

383. The low numbers of lesions on stems and petioles of Kanyoma and Mwitunde is of particular importance. It is the high incidence on these tissues in susceptible varieties that leads to rapid defoliation and break-up of the plants before normal maturity, and thus to great difficulty in mechanical harvesting. Current observations suggest that the lower rate of incidence on resistant varieties is associated with a smaller average stoma size, and that the rate of lesion expansion is slower because the leaf tissues are generally thicker.

384. A study was made of the relative prevalence of the two *Cercospora spp.* on the groundnut crop. It was found that, although the first attack of *C. personata* is recorded later in the season, its rate of build-up is so much more rapid than that of *C. arachidicola* that it becomes the major factor in any severe epidemic. However, with the universal planting of Mwitunde on the T.A.C. production farms at Nachingwea, the *Cercospora* complex has ceased to be a disease of any importance in the area. Defoliation of the crop is slight even at the date of harvesting of this long-season variety.

AMERICAN RUST DISEASE OF MAIZE

J. S. Hemingway

385. The most important disease in the T.A.C. areas is the rust of maize caused by *Puccinia polysora* Underw. The losses in yield due to rust infection are heavy. They have been estimated by the use of a " blanket " treatment of sulphur dust and by the comparision of plots planted on a series of dates. In the " blanket " experiments the disease caused a reduction of yield from 2749 to 1847 lbs. grain per acre. The lower yield is a result of a reduced number of cobs per plant, and a considerable reduction of the individual seed weight. There was no alteration of the carbohydrate/protein ratio of the seed.

386. The initial infection takes place at progressively earlier stages on later plantings, spreading from adjacent established epidemics ; but once the initial infection has occurred the rate of increase in any planting is uniform. Consequently the aim in any agronomic system of control lies in the delaying of the initial incidence on the main crop.

387. Field trials have been made with a number of lines segregating for resistance to rust to provide field data for checking against the E.A.A.F.R.O. " juvenile testing " method. A programme of breeding for the introduction of resistance from E.A.A.F.R.O. lines into the local variety " Katumbili " is well advanced, progress being accelerated by the use of irrigation during the dry season. The first generation for bulking-up homozygous resistant lines from a first back-cross with Katumbili is now established. The vigour of this material, with a constitution of 75 per cent Katumbili genes, is at least equal to that of normal Katumbili.

SOIL SURVEY AND MANAGEMENT

B. Anderson

388, *Soil Survey.* The soil survey of the T.A.C. lease at Nachingwea was continued, with the mapping of an area of about 6 square miles to the south of Nachingwea township. This survey demonstrates clearly that on the higher ground the composition of the parent rock often determines the overlying soil. In such places the soil has been formed directly from the rock below, without much movement. This contrasts with other parts of the Nachingwea lease, and with the whole of the Kongwa lease, where the weathering rocks appear to have been mixed together and differences in rock composition have little or no influence on the overlying soil. In this latest-surveyed area, bands of deep, red sandy loams (*Nachingwea* series) in places alternate with

bands of browner, much sandier soils which show a development of concretionary ironstone in the subsoil (*Namatula* series). These bands follow the grain of the gneiss of the underlying Basement Complex and cut across the catenary succession of soils down the slope.

389. The *Namatula* soils are derived from the more quartzose strata of the gneiss, as can be seen in occasional outcrops of the rock. There is little doubt that the *Nachingwea* soils arise from the more basic hornblende gneisses and amphibolites, though since these rocks weather more easily than the quartzose gneiss they rarely outcrop. It appears that the lesser development of concretionary ironstone in the red sandy loams is due partly to the lesser penetration of rain in these heavier soils and partly to the deep weathering of the basic gneisses, which does not permit the formation of a temporary perched water-table necessary for the formation of a concretionary horizon.

390. A detailed soil survey, on a scale of 1 in 5000, was also made of about 600 acres of land in a valley near Nachingwea township with a view to the increased utilisation of the soils in the area. The valley-bottom soils are in general more fertile than the upland soils. They have however not yet been used by the T.A.C. to any appreciable extent owing to the difficulties of flood control.

391. Three months were spent on secondment to the Rufiji Basin Survey team, and a reconnaissance soil map was made of the alluvial soils of the lower Rufiji valley. The area covered was about 600 square miles.

392. *Other Investigations.* The occurrence at Nachingwea of patches of soil very low in exchangeable bases, particularly calcium, was mentioned in the previous report. Such patches now appear to be fairly frequent to the east and south of Nachingwea township. The low value of the bases is in most cases inherited from the parent rock ; these patches follow the strike of the underlying rock. Two liming experiments were laid down on these low-base soils but no response to the lime was obtained in the first year. Since it is possible that the lime, which was applied shortly before the planting of the crop (sorghum), had not become sufficiently incorporated in the soil to influence the first crop, the experiment is being continued. It may be that the infertility of these soils is due not to a direct deficiency of calcium for crop growth but to some indirect effect. One possibility is that the soil is an unfavourable environment for the nitrifying bacteria. A possible deficiency of minor elements is also being borne in mind.

393. The occurrence of unfilled shells (" pops ") in the groundnut crop has been shown to be associated with low soil calcium. This is in agreement with American findings. In one field with a fairly high

incidence of " pops," there was a significant correlation between yield and exchangeable calcium for about 18 samples from different panels of the field (a panel being the portion of a field between two soil conservation terraces). Figures for the two highest yielding and two lowest yielding panels (pairs of panels in the latter case) are given in Table 1. The " bag weight," the weight of a full sack of unshelled nuts, is a measure of the proportion of filled pods. Both yield of unshelled nuts and bag weight are correlated with exchangeable calcium.

TABLE 1.

INFLUENCE OF SOIL CALCIUM ON GROUNDNUT YELDS AND VOLUME WEIGHT OF UNSHELLED PODS (at Nachingwea)

Panel No.	Yield lb/acre of pods	Bag weight lb.	pH (water)	Available Ca m.e./100g.
5	1072	69	5.61	2.2
3	984	65	5.91	2.6
16 & 17	467	57	5.92	1.3
18 & 19	430	44	6.15	1.5

394. Another case arose in a fertiliser experiment on groundnuts on a site with a rather low exchangeable calcium (1.9 m.e. calcium in 100g. soil). Muriate of potash considerably depressed the shelling percentage (*i.e.* kernels as a percentage of unshelled nuts) in the absence of superphosphate but had little effect in its presence (see Table 2). The adverse effect of the potassium is probably due to its antagonistic effect on calcium absorption, while the beneficial effect of the superphosphate is probably due to the calcium in the fertiliser rather than the phosphate.

TABLE 2.

GROUNDNUT SHELLING PERCENTAGES AS IINFLUENCED BY POTASSIUM AND PHOSPHATE FERTILISERS (at Nachingwea)

Potash	Single supers, lb/acre		
	0	100	200
	%	%	%
No potash	60.1	60.7	62.0
100 lb/acre muriate of potash	49.5	55.2	58.4

Significant differences 5% 4.9
1% 6.5

395. The soil laboratory carried out a considerable number of total nitrogen determinations on soils from Kongwa and Nachingwea. Many of the samples were from soil-profile pits and the figures show a general decrease in the carbon/nitrogen ratio with depth of sample. Topsoil samples from Kongwa have a carbon/nitrogen ratio near 10, while topsoil samples from Nachingwea have a ratio of about 18. Correspondingly, nitrogenous fertilisers have not, in general, given a response at Kongwa but have nearly always increased the yields of non-legumes at Nachingwea.

396. The 1955 season at Nachingwea was marked by unusually heavy rains in late January and in February. The maize crop, mostly planted in early February, showed symptoms of severe nitrogen deficiency in its early stages, before top-dressing with sulphate of ammonia. The local peasants say that maize and sorghum never yield well in years of heavy rain and it seems likely that this is largely due to the heavy leaching of nitrates in such years. Since nitrogen is a nutrient which can be supplied "on demand" by the plant, it appears that there is here a source of seasonal fluctuation in yield which could be ironed out by judicious use of nitrogenous fertilisers.

397. Apart from soil work, the soil laboratory continued to run a second-order meteorological station in association with the East African Meteorological Department. Collections were made of plants in the Nachingwea and Rufiji valley areas and sent to the East African Herbarium for identification. A collection of the species of *Brachystegia* found near Nachingwea was despatched to A. C. Hoyle of the Imperial Forestry Institute at Oxford.

WATER USE OF CROPS AND GRASSES

H. Brzstowski

398. Measurements of soil moisture-contents and soil temperatures under fallows, crops and grasses have been continued at Kongwa in co-operation with the Soil Physics Division of E.A.A.F.R.O., to whom samples and data are sent for study and interpretation. The range of soil-temperature observations was increased during the year in order to obtain further information on the thermal effects of grass covers. Evapo-transpiration tanks were set up and tested under *Cenchrus ciliaris* and *Eragrostis abyssinica.*

399. A more detailed account of this co-operative work will be found in the Section "The Application of Physics to Agriculture and Forestry"

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